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THE PHILIPPINE
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DISTRIBUTION OF THE DIPTEROCARPACEAE

ORIGIN AND RELATIONSHIPS OF THE PHILIPPINE FLORA AND CAUSES OF THE DIFFERENCES BETWEEN THE FLORAS OF EASTERN AND WESTERN MALAYSIA

By ELMER D. MERRILL
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EIGHT PLATES

In discussing the biological differences between eastern and western Malaysia, and in attempting to explain the reasons for the manifest differences between these two regions, various authors have considered the mammals, birds, reptiles, batrachians, mollusks, fresh-water fishes, and insects with or without reference to the geology, paleontology, hydrography, and climate of the entire region. It has long been known that there are striking differences between the floras of eastern and western Malaysia, but hitherto no direct comparison seems to have been made between them. How significant these differences are is strikingly brought out on page 24.

In this paper the term Malaysia is used to define the entire region from the Malay Peninsula to New Guinea, including the Philippines. Western Malaysia includes the Sunda Islands and the Malay Peninsula, that is, Sunda Land of Molengraaff; eastern Malaysia includes all the Islands east of the Macassar Strait, including New Guinea. For purposes of discussion the Philippine Archipelago is considered as an independent area.

In discussing zoögeographic alliances one fact that must not be overlooked is that, before any considerable fauna can exist in any region, the vegetation must be present. In other words,

we must of necessity assume for the Philippines, for example, that our flora developed antecedent to much of our fauna. It is, therefore, assumed that the geographic distribution of generic types of plants characteristic of the primary forests of Malaysia, eliminating those known to be distributed by the wind and by water, which are comparatively few, forms a more-reliable basis for tracing previous land connections than does the present-day distribution of most groups of animals.

The sharply defined family Dipterocarpaceae is essentially confined to India and Malaysia. It has no representative in tropical America or in tropical Australia, while in Africa it is represented by a single species of the genus *Vatica* and by thirteen species of the anomalous genus *Monotes*, which some authorities do not admit as a member of this family.

As at present understood, including the African genus *Monotes*, the family comprises seventeen genera and about three hundred seventy-seven species.[1] Excepting the African genus men-

TABLE 1.—*Geographic distribution of the genera and species of Dipterocarpaceae.*

Genera.	Total species.	Africa.	Seychelles.	Ceylon.	India.	Eastern Peninsula.	Sunda Islands.	Philippines.	Eastern Malaysia.
Anisoptera	16	------	------	------	------	6	4	4	4
Balanocarpus	17	------	------	1	2	8	5	2	------
Cotylelobium	6	------	------	1	------	2	4	------	------
Dipterocarpus	69	------	------	5	2	29	28	15	------
Doona	12	------	------	12	------	------	------	------	------
Dryobalanops	6	------	------	------	------	------	6	------	------
Hopea	56	------	------	3	4	18	28	7	3
Isoptera	2	------	------	------	------	1	2	1	------
Monoporandra	2	------	------	2	------	------	------	------	------
Monotes	13	13	------	------	------	------	------	------	------
Pachynocarpus	5	------	------	------	------	2	3	------	------
Parashorea	5	------	------	------	------	1	2	2	------
Pentacme	5	------	------	------	------	3	------	2	------
Shorea	95	------	------	6	3	41	46	13	3
Stemonoporus	13	------	------	13	------	------	------	------	------
Vateria	3	------	1	1	1	------	------	------	------
Vatica	52	1	------	3	1	24	16	4	4
Total species	377	14	1	47	13	135	144	50	14

[1] This estimate is primarily based on Brandis, D., An enumeration of the Dipterocarpaceae, Journ. Linn. Soc. Bot. 31 (1895) 1–148, *t. 1, 2.* His figures have been modified by certain reductions and transfers made since his paper was published, and species described since 1895 have been added.

tioned above, one species of *Vatica* that occurs in Africa, and a single species of *Vateria* that occurs in the Seychelles, the family is confined to India, Ceylon, the Eastern Peninsula (one *Shorea* in southeastern China and one *Vatica* in Hainan), the Sunda Islands, the Philippines, the Moluccas, Celebes, and New Guinea.

The Sunda Islands taken as a whole, that is, Sumatra, Java, Borneo, and the smaller intervening islands such as Bangka, Billiton, and Lingga, present the most numerous species, totaling one hundred forty-four in eleven genera. Of this area Borneo is specifically the richest in dipterocarps, presenting eleven genera and one hundred three species. The total number of species known from Sumatra is comparatively small, in all probability due chiefly to the fact that the Sumatran flora is very imperfectly known. The dipterocarp flora of Java is likewise poor, but this may be explained by the assumption that some dipterocarps that may have existed in Java have been exterminated in comparatively recent times, that is, within the past few centuries, through the almost complete destruction of the primary forests throughout Java below an altitude of 1,200 meters. Everywhere in Malaysia the destruction of the low-altitude, primary forest means the destruction of the dipterocarps. The Eastern Peninsula, from Assam through Burma, Siam, Indo-China to the southern part of the Malay Peninsula, presents eleven genera and one hundred thirty-five species.

The next richest area is the Philippines, with nine genera and fifty species, our dipterocarps being distributed throughout the Archipelago from Tawitawi in the Sulu Archipelago and Palawan through Mindanao and the central part of the Archipelago to northern Luzon and the Babuyan Islands. Five species in five genera occur in the latter group, between Luzon and Formosa. No representative reaches Formosa, and only a single species of *Shorea* is known from the southwestern part of Kwangtung Province, China, while a single species of *Vatica* occurs in Hainan.

India proper presents only thirteen species in six genera. In striking contrast to this, the small island of Ceylon presents no less than forty-seven species in ten genera, approximately the same number of species and genera as occur in the entire Philippine Archipelago. The Ceylon dipterocarp flora is further remarkable for its very definite endemism, the genus *Doona* with twelve species, the genus *Monoporandra* with two species, and the genus *Stemonoporus* with thirteen species being confined to

Ceylon; furthermore, the genus *Vateria* presents but three species, one occurring in Ceylon, one in India, and one in the Seychelles.

Perhaps the most striking feature in the distribution of the dipterocarps is their paucity in eastern Malaysia; that is, in the entire region extending from Celebes southward to Lombok, and eastward through the Moluccas to New Guinea, where only fourteen species in four genera are known. Four of these belong in the genus *Anisoptera,* three in the genus *Hopea,* three in the genus *Shorea,* and four in the genus *Vatica.* All of these genera are of wide geographic distribution, represented in most of the regions in which the family occurs. The genera *Hopea, Shorea,* and *Vatica* are three of the four large genera in the family. It seems probable, however, that the number of species generally recognized as occurring in eastern Malaysia is too high. Dr. D. F. van Slooten, who is now engaged in a general study of the Dipterocarpaceae of Malaysia, informs me under date of February 4 that, so far as his studies have been completed, he is of the opinion that the two species of *Anisoptera* described from New Guinea, and perhaps the undescribed one mentioned by Dyer, must be reduced to *A. polyandra* Blume. He is further of the opinion that the three species of *Vatica* recorded from the Moluccas should be reduced to a single one, *V. papuana* Dyer. The reduction in the number of species of *Vatica* is, however, counterbalanced by two apparently undescribed forms represented in the Buitenzorg Herbarium by imperfect material from Celebes.

It is perfectly evident that the Eastern Peninsula and the Sunda Islands are essentially the regions in which the family has reached its maximum development in genera and in species. India may possibly have supported a much richer dipterocarp flora in the past than to-day; this is especially probable in view of the fact that the comparatively small island of Ceylon, off the southern end of the Indian Peninsula, presents so many more genera and species than does the entire Western Peninsula.

In view of the large development of this family in the Sunda Islands, the Eastern Peninsula, and the Philippines, its slight development in eastern Malaysia, and the peculiar biological characters of the group (see p. 6), a study of the geographic distribution of the Dipterocarpaceae in the entire Malaysian region is of very special interest. This interest lies in a logical

explanation of the differences between the floras of eastern and western Malaysia, and why the Philippines, lying to the northeast of the Sunda Islands or western Malaysia and north and northwest of eastern Malaysia, presents in its flora elements from both of these two rather sharply differentiated regions of the Malay Archipelago.

We know comparatively little regarding the geological history of the Dipterocarpaceae. Brandis [2] states regarding the five fossil species, described by Geyler from Borneo and Labuan and placed in the genera *Hopea* and *Dipterocarpus,* that the fragments show no characters which necessitate their being placed in this family. He considers that the only fossil remains described up to 1895 that could safely be classed here are those described by Heer from the Tertiary deposits of Sumatra. Heer describes two species of *Dipterocarpus,* one of which Brandis thinks probably was a species of *Shorea.* Brandis concludes that the fossil remains, therefore, throw no light upon the development of this family.

Comparatively little additional information regarding fossil Dipterocarpaceae has become available since Brandis's work was published. Holden [3] has described a fossil genus, *Dipterocarpoxylon,* from the Tertiary of Burma, based on fossil wood of a single species. Colani [4] has described another species of this genus from Tertiary material supposed to have come from Annam.

Schuster [5] records *Hopea fagifolia* Miq. and *Vatica lancifolia* Miq. from the Trinil beds in Java (Pleistocene). There seems to be no question that Schuster's identification of these fossil remains is correct.

Edwards [5a] has very recently described a new genus and species, *Dipterocarpophyllum gregoryi,* from the Tertiary of southeastern Burma which, however, is in all probability not distinct from some living genus. He cites Crié's description of

[2] Brandis, D., An enumeration of the Dipterocarpaceae, Journ. Linn. Soc. Bot. 31 (1895) 4.

[3] Holden, R., Records Geol. Surv. India 17 (1916) 267.

[4] Colani, M., Service Geol. Indochine Bull. 6 [3] (1919) 2.

[5] Schuster, S. J., Monographie der fossilen Flora der Pithecantropus-Schichten (1911) 1–70, *t. 1–27.* Reprint from Abhandl. Kgl. Bay. Akad. Wissensch. Math.-Phys. Klasse 25 (1911).

[5a] Edwards, W. N., On some tertiary plants from South-East Burma, Geol. Mag. 60 (1923) 159–164, *t. 5.*

Phyllitis dipterocarpoides from the Pliocene of Java, which is compared to the living *Dipterocarpus baudii* Korth., Kraüsel's *Dipterocarpoxylon tobleri* from the Miocene of Sumatra, and also the latter's reference of *Grewioxylon swedenborgii* Schuster from the East Indies to *Dipterocarpoxylon,* together with the description of *D. javanense* Kräusel from the Tertiary of Java. He further notes that *Woburnia porosa* Stopes, from the English Lower Green Sand (Lower Cretaceous) has been compared with the Dipterocarpaceae, thus indicating that the family may have had a long geologic history and a more-extended distribution in the past.

Fossil Dipterocarpaceae found in the Philippines and appertaining to the genera *Anisoptera* and *Shorea,* like those of the Trinil formation in Java, are absolutely identical with species now living in the Archipelago. The formation at Sagada, Luzon, which has yielded a large number of leaf impressions, is Pliocene. The Dipterocarpaceae represented here are *Anisoptera thurifera* Blume, *Shorea guiso* Blume, and *S. polysperma* Merr. Genera of other families, such as *Calophyllum, Beilschmiedia, Diplodiscus, Cinnamomum,* and *Phoebe,* are represented only by existing forms, and all species found are associates of the dipterocarps in our low-altitude primary forests of to-day.

We now know enough of the geological history of the Dipterocarpaceae to state definitely that this family was developed and widely distributed in India and Malaysia in late Tertiary times, and that it probably developed as a family in southern Asia and in what is now western Malaysia when the Sunda Islands were united with the Asiatic continent. It arose, perhaps, in the early Tertiary or in the late Mesozoic. So far as the Philippines is concerned, our Dipterocarpaceae reached the Archipelago during the Pliocene or earlier, as, judging from the nature of the fossil deposits known in Luzon, representatives of this family were apparently dominant in the primary forests of that time, as they are to-day.

It is a peculiar biological character of this family that, with almost no exception, the numerous species are essentially confined to the primary forests. They do not thrive in the open country and are never components of young secondary forests or of forests that rapidly spring up in deforested areas that are allowed to revert from cultivation where grass fires are not a

limiting factor. Brandis[6] has called attention to the fact that not only are various species gregarious or semigregarious, but the sal, *Shorea robusta* Gaertn. f., stands much shade when young. Brown[7] verifies this observation in the case of the Philippine *Parashorea malaanonan* (Blanco) Merr.; his data and graph showing the rates of growth indicate clearly that *Parashorea* withstands a greatly prolonged suppression period. This is especially true of the seedling and sapling stages where the start is made in the virgin forest. Brown shows that the suppression period is so great in the primary forest that as much as seventy years may elapse before the trunk attains a diameter of 5 centimeters, although the rate of growth after this long suppression period is very rapid. It would seem that all or most dipterocarps have this adaptability to a long supression period in early life; hence their ability to thrive in and eventually to dominate the dense primary forests of India and Malaysia.

Most dipterocarps have winged fruits, yet they are definitely not adapted to wide dissemination by wind. The fruits are in general too heavy for wind distribution, while the wings are adapted to provide a gyratory motion in falling, rather than for horizontal distribution. Except in the genera *Vatica* and *Isoptera,* the seeds or fruits do not present the slightest adaptation for dissemination by water. Burkill[8] briefly discusses the adaptation of the fruits of *Vatica wallichii* Dyer and *Isoptera borneensis* Scheffer for dissemination by water. He finds that the fruit of the former floats for an average period of twenty-two days, while that of the latter, deprived of its corky sepals, sinks within a period of sixty hours. He states that it is not possible to regard water distribution as in any way ancestral in the order. Generally speaking, the seeds of the dipterocarps are noted for their brief period of viability; they do not in general withstand drying out, which is perhaps one very potent reason for their practical nonoccurrence in open places. The trees from seed and seedling stages to full maturity are clearly adapted to the shade, temperature, moisture, and light conditions characteristic of the dense tropical primary forests of India and Malaysia. To

[6] Brandis, D., Journ. Linn. Soc. Bot. 31 (1895) 6.

[7] Brown, W. H., Vegetation of Philippine Mountains, Bur. Sci. Publ. 13 (1919) 157, *fig. 2.*

[8] Journ. Straits Branch Roy. Asiatic Soc. 86 (1922) 276, 281.

one, then, familiar with the dipterocarps as they occur in nature, with the habitat complex of most or all species, with their seed and seedling characters, and especially with their peculiarly short-lived seeds, it becomes perfectly evident that, in order to explain their present geographic distribution, it is absolutely necessary to postulate previous land connections from India to New Guinea over which, at some time in geologic history, it has been possible for certain species to march unimpeded.

From the geologic history of the Philippines we know that its present fauna and flora, or their ancestors, originated outside of the present-day limits of the Archipelago; no geologic formation earlier than the Jurassic is known from the Archipelago. From the very nature of the Dipterocarpaceae they must have originated in a forested region; therefore, the Philippines must have been a forested region before the dipterocarps arrived. The rate of dissemination of the dipterocarps is relatively slow, so that a long period must have elapsed during which land connection existed between the Philippines and western Malaysia, over which the trees migrated. From the adaptability of these trees to primary forest conditions (soil, humidity, rainfall, and temperature conditions practically wherever they occur with us being favorable to their development) they have become dominant.

Dipterocarp forests are tall, characteristically low-altitude, tropical ones of India and Malaysia, and usually occupy localities most favorable to tree growth. They occur on all types of topography, but are usually best developed on well-watered and well-drained plains and on the lower gentle slopes of the main mountain masses. They thrive best perhaps in the humid localities of Malaysia, where dampness and humidity are always so great that forest fires are unknown; yet in some regions, such as Bengal, the sal (*Shorea robusta* Gaertn. f.) thrives in localities where the dry season is so pronounced that fires cause considerable damage to the forests. While most of the species are very strictly tropical and, in the Tropics, low-altitude forms, the sal occurs in some parts of Bengal where it is injured by frost.

The dipterocarp forests of the Philippines reach their maximum development below an altitude of 700 meters, and ordinarily few species are found at or above an altitude of 800 meters. In Luzon and the central Philippines the only species recorded from altitudes of 800 meters are *Vatica mangachapoi* Blume and *Shorea polysperma* Merr., and we have no records

of these from above that altitude. On the authority of Mr. A. D. E. Elmer, we find in Mindanao *Parashorea warburgii* Brandis, *Shorea squamata* Dyer (= *S. palosapis* Merr.), and *S.* sp. at 1,000 meters altitude, and *Vatica mindanensis* Foxw. at 1,100 meters altitude.

In connection with the altitudinal range of the Dipterocarpaceae in the Philippines, it is interesting to compare the data compiled by Brown [9] in the midmountain forests of central Luzon; that is, between 600 and 900 meters altitude. At an altitude of 700 meters a plot 50 meters square was selected with the same slope and exposure as those of the plot surveyed in the dipterocarp forest at 450 meters altitude. In this plot he found five hundred seventy-eight individual trees, representing thirty-nine species, but the Dipterocarpaceae were entirely absent. However, most of the species found in this plot occur also in the dipterocarp forest at lower altitudes. In other words, Brown definitely shows that the Dipterocarpaceae are strictly limited as to their altitudinal range, while representatives of many other families and genera, which are associated with the Dipterocarpaceae and form the complex, low-altitude forests of the Philippines, thrive at altitudes distinctly higher than the Dipterocarpaceae themselves.

Brown states that in the transition from the dipterocarp to the midmountain forest the change from one association to another is usually gradual and is marked by intermediate conditions. The tall trees characteristic of the Dipterocarpaceae that form the upper story of the typical dipterocarp forest gradually disappear, and the first story of the *Quercus-Neolitsea* association of the midmountain forest is approximately of the same height and composed largely of the same species as the second story of the dipterocarp forest. There is no marked change in the composition of the minor elements in the transition zone.

In reference to the altitudinal range of the dipterocarps outside of the Philippines, Mr. I. H. Burkill, Director of the Botanic Gardens, Singapore, informs me under date of January 8 that, on the main range of the Malay Peninsula in the neigborhood of Semangkok Pass, he and Mr. Holttum found that they disappear at an altitude of about 1,050 meters without apparent dwarfing. The forest here at an altitude of about 1,200 meters

[9] Brown, W. H., The Vegetation of Philippine Mountains (1919) 76–97.

is 30 meters high but, with the intrusion of the dipterocarps at and below 1,060 meters, the height abruptly increases to 60 meters.

In most dipterocarp forests the ground is bare and herbs are scarce. In the *Quercus-Neolitsea* association of the midmountain forest there is in most places a well-developed ground covering of herbs. The change takes place not in the tension zone between the two associations but in the upper part of the dipterocarp forest. Brown further calls attention to the fact that the midmountain forest is more open than the dipterocarp forest, but here again the change is a gradual one and begins in the upper part of the dipterocarp forest; he states, furthermore, that the increase of epiphytes is much greater in the midmountain forest, this being due to the general complex of conditions that cause increased epiphytic vegetation as higher altitudes are reached. There is no marked change either in amount or composition of this vegetation on the border between these two associations. In these midmountain forests there are no dominant trees corresponding to the dipterocarps in the forests at lower altitudes.

To those unacquainted with the primary forests of India and Malaysia it is difficult to convey an impression of how absolutely dominant the dipterocarps are in these vast forested areas. Brandis has emphasized the fact that numerous species are gregarious, forming nearly pure stands of large extent where single species occur to the practical exclusion of all others. He is entirely correct in his statement that the dipterocarps in the tropical forests of eastern Asia play the rôle which in Europe (and for that matter North America) belongs to the Coniferae and Cupuliferae. The most noted gregarious species is the sal, *Shorea robusta* Gaertn. f., which forms pure or nearly pure forests of vast extent in the Himalayan foothills and in eastern central India. Brandis enumerates seventeen species in seven genera that are known to be gregarious. In addition to these gregarious species very many more are semigregarious; but practically wherever they occur, even though as scattered individuals, they dominate and give character to the forests on account of their great size (see Plates 3–8).

Owing to the fact that these forests contain a high percentage of commercial timber, they have been intensively studied in India, Malaysia, and the Philippines. The Philippine diptero-

carp forests have been especially considered by Whitford,[10] by Brown and Matthews,[11] and by Brown.[12]

Whitford,[13] in discussing the dipterocarp forests on the lower slopes of Mount Mariveles in Bataan Province, Luzon, enumerated the trees in four plots, varying in size from 300 to 750 square meters, between altitudes of 260 and 410 meters. He found in these plots three hundred eighty-eight individual trees, representing eighty-eight species, of which six species were representatives of the Dipterocarpaceae. Three species, namely, *Dipterocarpus grandiflorus* Blanco, *Shorea polysperma* Merr., and *Parashorea contorta* Merr. and Rolfe, comprised 31.6 per cent of all the trees in the plots mentioned, and further, with the exception of one species of *Calophyllum,* one species of *Santiria,* one of *Eugenia,* and a few others, these trees made up nearly the whole of the upper-story vegetation. The other dipterocarps in the plots were *Anisoptera thurifera* Blume, *Hopea acuminata* Merr., and *Dipterocarpus vernicifluus* Blanco. Brown [14] enumerated the individual trees growing on plots 50 meters square on the lower slopes of Mount Maquiling, Laguna Province, Luzon. In one plot at 450 meters altitude in a virgin dipterocarp forest he found three hundred fifty-three individual trees, representing ninety-two species, of which three species and twenty-nine individuals were Dipterocarpaceae. In a culled dipterocarp forest at an altitude of 200 meters, of the same area as the one discussed above, he found a total of eight hundred eighty-seven individual trees representing one hundred twenty-nine species, the Dipterocarpaceae being represented by three species and eighty-one individuals. Even when the individual dipterocarps are few in number they dominate the forest by their great size (see Plates 5 and 6).

After this preliminary examination of the geographic distribution of the dipterocarps, a brief discussion of the paleobotanical data available, the peculiar biological characters of the family, and a general description of the dipterocarp forests in

[10] Whitford, H. N., The vegetation of the Lamao forest reserve, Philip. Journ. Sci. 1 (1906) 373–431, 637–682, *t. 1–45.*

[11] Brown, W. H., and Matthews, D. M., Philippine dipterocarp forests, Philip. Journ. Sci. § A 9 (1914) 413–561, *t. 1–13.*

[12] Brown, W. H., The Vegetation of Philippine Mountains: The relation between the environment and physical types at different altitudes, Bur. Sci. Publ. 13 (1919) 1–434, *t. 1–41,* pp. 27–75.

[13] Op. cit. 640.

[14] Op. cit. 440.

which the absolute dominance of the dipterocarps in the typical primary forests of Malaysia is brought out, we may now take up the significance of the dipterocarp distribution in the Malay Archipelago.

We have already noted (p. 3) that the two rich areas are the Eastern Peninsula, with eleven genera and one hundred thirty-five species, and the Sunda Islands, with eleven genera and one hundred forty-four species, while the Philippines stands third, with nine genera and fifty species. Why do we not find the family strongly developed in the islands south of the Philippines and east of the Macassar Strait between Borneo and Celebes, or Wallace's Line? It has been noted above that in this vast region only fourteen species in four genera are known. Had there been a continental area extending from Sumatra to New Guinea at any time while the Dipterocarpaceae was developing its geographic distribution, we should certainly expect to find approximately as many dipterocarps in eastern Malaysia as we do in western Malaysia, or at least as many as in the Philippines. In the entire region from Celebes to New Guinea climatic and other factors are approximately the same as in western Malaysia; in other words, the entire region is essentially adapted to the requirements of the Dipterocarpaceae. Celebes is also infinitely closer to Borneo geographically than is the main part of the Philippine group.

In past geologic times much of the area between southeastern Asia and Australia has been occupied by epeiric seas. Dr. Roy E. Dickerson calls my attention to the facts that Java, Sumatra, and Borneo are in large part covered by marine Tertiary sediments and that New Guinea is also largely composed of similar sediments; the sediments in British New Guinea are largely Miocene. The islands of Java, Sumatra, and Borneo on the one hand, and New Guinea on the other hand, are land masses associated with shelf seas which have consequently during Tertiary times been alternately dry and flooded by shallow seas. Practically throughout the Tertiary New Guinea, Celebes, Borneo, Java, and Sumatra have changed their patterns from epoch to epoch. During the Pleistocene Java, Sumatra, and Borneo were alternately connected and disconnected with the Asiatic mainland, and New Guinea was alternately connected and disconnected with Australia. Formosa has had the same history in reference to Asia. The great difference between the regions now delimited by the Asiatic and Australian continental shelves and the intermediate insular area (the stress area between these two

great continental shelves), is the presence of great development during Pleistocene times in the intermediate stress area of very notable marine deeps and corresponding upthrust island masses.

In the Philippines there is strong suggestive evidence that some of our deeps, such as those connected with the Formosan and Mindanao Rift systems, were formed and reformed repeatedly during the Tertiary. There is even stronger evidence to show that the Formosan Rift originated in the Tertiary and that movements along this great rift during that time have maintained a constant separation between Formosa and the Philippines. Doctor Dickerson concludes, from a study of the Malumbang strata, which is widely distributed in the Philippines, that only shallow seas existed in the Philippines during the Pliocene. In the Philippines the earliest geologic formations that have been recognized are the Jurassic of the early Mesozoic. The Cretaceous, the Eocene, and the Oligocene formations are absent in the Philippines, or at least have not been recognized by geologists, so far as geologic exploration of the Archipelago has progressed.

Molengraaff's [15] concise summary of our present knowledge of the land and sea areas in the Malaysian region gives us the clue to the cause of the biological differences between eastern and western Malaysia. His very definite conclusions cannot be ignored by any student of the distribution of the flora and fauna of this region.

In the Asiatic-Australian region there have been two definite continental platforms now delimited by the Asiatic and the Australian continental shelves, and since the early Tertiary these have been separated by an area which has been constantly in an archipelagic condition. The 200-meter line may be conveniently taken as delimiting these continental shelves, but the average depth of the water on these shelves is only 60 meters. The Asiatic shelf carries upon it all the Sunda Islands, Sumatra, Java, Borneo, and the intervening smaller islands; the Australian shelf carries upon it the great island of New Guinea. In the Pleistocene and, probably, in the immediately preceding epoch Sumatra, Borneo, Java, and the islands eastward of Java to and including Bali, as well as the Balabac-Palawan-Calamian group in the Philippines and probably the Sulu Archipelago, were connected at times with the Asiatic continent via Borneo, and New Guinea was connected with Australia.

[15] Molengraaff, G. A. F., Modern deep sea research in the East Indian Archipelago, Geogr. Journ. 57 (1921) 95–121, *figs. 1–9*, map.

Interposed between these two continental platforms we have an intermediate area radically different in its physical features and in its Pleistocene geological history. This area is one of inclosed, troughlike sea basins of great depth, ranging from 1,200 to 6,000 meters; elongated islands, mostly presenting very considerable altitudes, their elongation parallel to the troughs; the troughlike basins and the islands arranged in curved lines; and the islands presenting very conspicuous signs of comparatively recent elevation. This modern elevation in the Philippines in places exceeds 1,500 meters. Most of the inclosed deep sea basins are in the eastern part of the Archipelago; none of them actually occur within the limits of the area outlined by the Malay Peninsula, Sumatra, Java, and Borneo (see Plate 1).

Molengraaff's contention that there is a genetic connection between the subsidence of the trough-shaped deep sea basins and the elevation of the adjoining, elongated, paralleling, elevated islands is an entirely logical conclusion. The explanation is a crustal movement in a process of folding or faulting at a certain depth. In other words, we have a large stress area, orogenetically still active and as a result unstable, situated between two stable areas, the latter delimited by the Asiatic and Australian continental shelves. This unstable area extends from Lombok and Celebes to near western New Guinea and northward through most of the Philippine group. This entire stress area has been orogenetically active and hence unstable from the Pleistocene, and possibly earlier. It has in consequence been archipelagic rather than continental, at least since the beginning of the Pleistocene. There have been intermittent land connections eastward to New Guinea, northward to the Philippines, and apparently southwestward and westward with Java, but probably during the entire Tertiary there was no direct connection across the narrow Macassar Strait between Celebes and Borneo.

In interpreting probable previous land connections on the basis of the present distribution of plants and animals it is difficult to assign definite values to special groups. We merely know that mammals generally cannot swim across broad separating seas; true fresh-water fishes are also thus limited; batrachians, while adapted to terrestrial life, are primarily adapted to fresh-water marsh conditions, and cannot live in salt water; lizards and snakes are apparently better adapted to fortuitous distribution from one island to another by drift than are the mammals as a group, certainly the larger mammals; birds, bats, and most insects, of course, have the advantage of flight, yet many groups

of birds and insects are curiously limited in distribution, indicating that some at least do not extend their range except over continuous land areas. Each specialist is, of course, interested in his own group, and it is but natural that he should be influenced in his deductions by his own special knowledge and his own special interests. Thus Pelseneer,[16] on the basis of certain geographic distributional studies, abandoned Wallace's Line and constructed a new one east of Celebes and Timor; this new line, which he called Weber's line, is absolutely untenable when all groups of animals are considered, even as Wallace's Line is untenable as an absolutely separating boundary.

Weber's Line is, however, apparently the approximate eastern boundary of the geologically unstable intermediate insular area, and bears much the same relationship to the Australian continent that Wallace's Line bears to the Asiatic continent. It seems to be clear that different portions of these lines have distinctly different values (see Plate 2).

Wallace's Line, so named by Huxley, was placed between Bali and Lombok, extending northward through the Macassar Strait between Borneo and Celebes and thence turning to the eastward between Celebes and Mindanao, extending into the Pacific Ocean. It was based on observations and published statements of Alfred Russell Wallace regarding the evident differences in the biology of eastern and western Malaysia. Critics of Wallace's Line have not always been entirely fair to Wallace. In his Island Life he clearly states that Celebes, although included by him in the Australian region, from a balance of considerations, almost equally belongs to the Oriental Region, and that it consequently must be left out of account in the general sketch of the zoölogical features of the Australian Region. Again, he speaks of it as an "anomalous island" because both by what it has and by what it wants it occupies such an exactly intermediate position between the Australian and Oriental Regions.

In reference to the position of Wallace's Line, our present data seem to show that this fundamental dividing line does not turn to the east between Celebes and Mindanao, but extends northward through the Sibutu Passage, the Sulu Sea, and the Mindoro Strait between the Calamian group and Mindoro, thence northward and then eastward between Formosa and the Batan Islands into the Pacific. The extension of this line north of

[16] Pelseneer, P., La ligne de Weber, limite zoologique de l'Asie et de l'Australie, Bull. Acad. Roy. Belg. (1904) 1001–1022.

the Macassar Strait, like its southward extension between Bali and Lombok, has not been of so long-continued and permanent a nature as the Macassar Strait (see Plate 2).

Weber's Line extends between Timor and Australia, running northwestward between the Kei and Aru Islands, then turns to the northeast and east through the Ceram Sea north of Ceram and Buru, and finally northward through the Molucca Passage and into the Pacific Ocean between Celebes and Halmaheira. Molengraaff [17] states that the trough sea or series of trough seas consisting of the Timor Sea separating Timor from Australia, the Kei trough, the Ceram trough, and the Ceram Sea is a most important geologic boundary, as it separates totally different structures from each other. He states that the nonvolcanic islands of this arc originated as oceanic ones by anticlinal folding and that, geologically, they stand in close relationship with eastern Asia but have no connection at all with Australia. If we are to accept a geologic boundary between Australia and Asia, then the boundary must be drawn between Timor and Australia and between Ceram and New Guinea. This sharp geologic boundary is also an important dividing line from a zoögeographic standpoint, as Weber has pointed out, for the fresh-water fishes. Molengraaff notes that the boundary is not so sharp a dividing line in other groups of animals as is the case with the fresh-water fishes but, in spite of this, it is important for all groups. It would seem that the significance of Weber's Line, like that of Wallace's Line, as a biological boundary, is due primarily to fundamental geologic conditions. Wallace's Line cannot be abandoned in favor of Weber's Line or vice versa; the former is merely the eastern boundary of the unstable insular area, and the latter is apparently the approximate western boundary of the same terrane and bears much the same relationship to New Guinea and Australia as Wallace's Line bears to Asia or, rather, the former eastern boundary of the Asiatic continent.

Weber,[18] followed by Van Kampen,[19] has clearly shown that the entire region from Celebes and Lombok to New Guinea is a

[17] Geologie in: De zeeën van Nederlandsch Oost-Indië (1921) 272–357, *t. 1–7*.

[18] Weber, M., Der Indo-australische Archipel und die Geschichte seiner Tierwelt (1902).

[19] Van Kampen, P. N., De Zoogeografie van den Indischen Archipel, Nat. Tijdschr. Nederl. Ind. (1909) Bijblad 3, 4; English translation, Am. Nat. 45 (1911) 537–560.

transition one, in which the Indian and Australian faunas mingle, where from east to west Australian types diminish rapidly, and where from west to east the Asiatic types decrease. The decreases are most startling in some groups, for instance, the true fresh-water fishes. In this group Sumatra presents two hundred twelve species, Borneo two hundred ninety-two, Java one hundred thirty-one, and Celebes only four. Such distribution is significant in itself. A very few fresh-water fishes entered Celebes by some fortuitous circumstances, and it is not at all surprising that one entered Lombok. Weber [20] thus lays entirely undue stress on the finding of a single cyprinoid in Lombok, overlooking the real significance of the very numerous cyprinoids in "Sunda Land" and their entire absence east of Lombok and Sumbawa. Here is a most excellent illustration of an efficient and long-continued barrier to the migration of the fresh-water fishes eastward in the form of narrow arms of the sea which they could not cross. That a very few, by fortuitous circumstances, did succeed in crossing this line in several hundred thousand years, is utterly insignificant in view of the very large number that occur west of this line.

Barbour [21] states the case thus:

> Neither Wallace's nor any other line can be held to form a real zoölogical boundary. A transition zone *with a fairly definite western frontier* [italics mine] and with an eastern frontier incapable of equally clear definition seems really to be the condition which serves to separate the Malayan from the Papuasian subregions. This zone may be about equally well defined for any of the groups of land animals, and the boundaries for the distribution of the several groups coincide with reasonable accuracy.

It is realized fully that the region under discussion is a transition one; that no sharp line can be drawn anywhere that will separate the Australian and Asiatic floras and faunas, or those of eastern and western Malaysia, when all groups are taken into consideration. The real significance of Wallace's Line is that it delimits and separates two regions that fundamentally have had a different geological history; one at times a continent over which plants and animals could march unimpeded except by such barriers that continents usually present, the other a constant archipelago where intermigrations have been inter-

[20] Weber, M., Siboga-Expedetie. Introduction et description de l'expédition (1902) 16.

[21] Barbour, T., A contribution to the zoögeography of the East Indian Islands, Mem. Mus. Comp. Zool. Harvard Univ. 44 (1912) 1–203, *t 1–8*

rupted by deep arms of the sea since the early Tertiary at least. The "fairly definite western frontier" of Barbour is Wallace's Line. In the unstable area land connections between what are now individual islands have been intermittent and, as between these islands and the lands to the east and west, the connections have apparently never been more than narrow isthmuses. In other words, intermigrations in the entire region from Lombok and Celebes eastward to New Guinea and northward through the Philippines have been inhibited by the generally constant archipelagic condition of the entire region. In reference to Borneo and Celebes the Sarasins [22] state that, as Celebes and Borneo do not present a single animal in common that is not found also in Java, Sumatra, or the Philippines, there is not the slightest possibility that a direct land bridge ever existed between Celebes and Borneo across the Macassar Strait since early Tertiary times. That there were indirect connections via the Sulu Archipelago, Mindanao, and the Sangi Islands to the north, and between Celebes and eastern Java by way of the Postilion and Paternoster islets, Bali and Lombok to the south, is entirely probable; in fact, almost certain.

I cannot accept Schuster's [23] general conclusions regarding the climate and vegetation of Pleistocene times in Java, nor his explanation of the geologic sequence of land connections in eastern Malaysia. Making due allowance for some manifestly erroneous identifications on his part,[24] I can see no reason for considering that, at the time the Trinil beds were formed, the low-altitude Javan climate was cooler than it is to-day. The altitudinal range of many of the species listed by him does not conform to their actual occurrence in nature; most of them, both in Java and in the Philippines (so far as they occur here), are low-altitude forms, even though some may exceptionally extend to and above an altitude of 1,200 meters. That in Pleistocene times the forests of Java were "typische Regenwälder der gemässigten Zone" positively cannot be accepted. His own

[22] Sarasin, P. und F., Materialen zur Naturgeschichte der Insel Celebes, III. Ueber die geologische Geschichte der Insel Celebes auf Grund der Thierverbreitung (1901).

[23] Schuster, J., Monographie der fossilen Flora der Pithecantropus-Schichten (1911) 1–70, *t. 1–27*. Reprint from Abhandl. Kgl. Bay. Akad. Wissensch. Math.-Phys. Klasse 25 [6] (1911).

[24] Thus, *Viburnum coriaceum*. While perhaps the correctness of the identification cannot be proved or disproved, the figure may just as well represent some species in any one of a half-dozen other genera in as many families.

list of species definitely shows that they were, like those of to-day, *typical low-altitude tropical forests.* I fail to see how the claim can be substantiated that, as a result of the cooling off in Pleistocene times, the vegetation was dislocated an entire height zone (approximately 800 meters). Incidentally, this would involve at most a change in the mean average annual temperature of but about 5° C., if we may judge Pleistocene weather conditions by modern ones in the Philippines and Java (see Table 2). It seems more probable, if there was any appreciable change in temperature at low altitudes in Java during Pleistocene times, that it was even less than is here indicated as the modern difference between the first and the second height zones. In temperate regions the difference in average temperature required to cause Pleistocene glaciation is estimated at but 6° C., but this difference in tropical regions would be relatively insignificant.

TABLE 2.—*Mean annual temperatures for various stations in the Netherlands East Indies, and the Philippines at sea level and at the approximate lower level of the second vegetation zone.*

	Altitude.	Mean annual temperature.
	m.	°*C.*
Batavia	8	26.03
Pasuruan	7.5	26.7
Manila	0	26.6
Los Baños	80	26.1
Glambock Selong	1,120	19.4
Bandoeng	730	22.2
Fort de Kock	920	21.0
Kajoemas	1,060	20.2
Mount Maquiling	740	21.4
Dansalan	701	22.8
Ganasi	735	23.7
Sumilao	740	23.5

Doctor Schuster, like others, disproves the existence of Wallace's Line, basing his refutation upon his interpretation of the paleobotanical evidence. He claims that Wallace's Line existed in Pleistocene times just as little as it does to-day. Schuster to the contrary notwithstanding, the botanical evidence, like the zoölogical, geological, and hydrographic evidence, indicates a definite distinction between eastern and western Malaysia. The principal part of the line of demarcation is the Macassar Strait, geologically the oldest part of Wallace's Line.

Doctor Schuster postulates successive waves of migration of Asiatic types to the east in Pliocene times, of which he differen-

tiates three, all starting in the Himalayan region, the first of which reached Australia, the second only as far as the Philippines and Celebes, while the third terminated in Java. These successive invasions necessitated corresponding land connections. In reverse order, the corresponding land bridges disappeared from east to west, and thus established more and more contracted limits to the spread of western elements. How illogical this explanation is can readily be seen in the westward distribution of Australian types of plants and animals. If the first break came east of Celebes we would logically expect to find about as many Australian types west of Celebes as we find in Celebes, for according to Schuster Celebes would then be connected with Asia As a matter of fact, Australian types of animals are practically absent in western Malaysia, while very few Australian types of plants are to be found here, in contrast to the considerable number of both found in Celebes, in eastern Malaysia as a whole, and in the Philippines. Barbour [25] notes that the supposed Papuasian element in the Javan fauna, which has been emphasized by Warner, is probably entirely nonexistent. He states that the fauna of Sumatra, Borneo, and Java has been entirely derived from the Malay Peninsula region. If Schuster be correct we would also expect to find in Celebes a considerable number of Dipterocarpaceae, proportionally as many as we have in the Philippines. Doctor Molengraaff's explanation of the geologic history of eastern Malaysia is more logical and more convincing than is that of Doctor Schuster.

From the data presented by Doctor Schuster my general conclusions would be that the low-altitude Pleistocene climatic conditions in Java were approximately identical with those existing to-day; that the forest flora represented in the Trinil beds was practically the same as the low-altitude tropical forests of western Malaysia as they exist to-day; and that, hence, these forests were definitely tropical ones and not at all of the temperate-zone type.

The most important fact brought out by Doctor Schuster is that the low-altitude Pleistocene Malaysian flora was practically identical with our modern one, indicating how very slow specific changes have been in Java, which is also true in the Philippines. The Javan Pleistocene fossil flora and the Luzon Pliocene fossil flora present only impressions that can absolutely be

[25] Op. cit. 165.

matched by living plants, the time element involved being several hundred thousand years. The Pliocene and Pleistocene Malaysian floras were not, then, radically different from the modern flora, being practically identical with that which exists to-day in the primary forests of Malaysia. Great changes in the floras of temperate regions are admitted for these epochs, but the equatorial region of Malaysia presents almost no changes, even in species. We may then consider that our present flora, that is, of the forested regions, is a Pliocene and Pleistocene one that has persisted with comparatively slight modifications. This involves the assumption that there were practically no changes in the general climatic conditions in the equatorial regions of Malaysia at low altitudes during the periods of great extension of the ice caps in the temperate zones, and this assumption is substantiated by the Pliocene and Pleistocene fossil marine faunas of both Java and the Philippines.

With this digression regarding the geologic history of the Malaysian region, we may now return to the subject of the geographic distribution of the dipterocarps and its bearing on the origin of the Philippine flora. The facts regarding their distribution have already been stated. The conclusion to be drawn from the paucity of forms in eastern Malaysia is perfectly evident. While the various forms could spread easily over the continental area comprising what is now southern Asia and the Sunda Islands, and to a very definite degree into the Philippines over the Sulu and Palawan bridges, they could not cross the narrow sea channels separating Borneo from eastern Malaysia. Only a few forms succeeded in reaching Celebes, the Moluccas, and New Guinea, and these by the roundabout routes over intermittent and always narrow connecting isthmuses from Mindanao to Celebes via the Sangi Islands, and to Gilolo and New Guinea via either Celebes or Talaut Island. Possibly a few came from Java through Bali, Lombok, and what are now the Postilion and Paternoster islets to southwestern Celebes.

In this connection it is of definite interest to examine Diels's recent paper on the Dipterocarpaceae of New Guinea.[26] He enumerates ten species in four genera for New Guinea; namely, *Anisoptera*, four; *Hopea*, three; *Shorea*, one; and *Vatica*, two. Of these *Hopea celebica* Burck is otherwise known from Celebes, and *Vatica papuana* Dyer from the Aru Islands, the others so

[26] Diels, L., Die Dipterocarpaceen von Papuasien, Engl. Bot. Jahrb. 57 (1922) 460–463.

far as known being confined to New Guinea. He states that the family plays an unimportant rôle in Papua and considers that there is no reason to believe that future investigations will greatly increase the number at present known.

He makes the significant statement that, while the species hitherto established are in part too imperfectly known to allow of positive systematization, those that are sufficiently well known stand in close relationship with species of Celebes and the Philippines; there are no apparent indications of independent form structure for the New Guinea species. He concludes that the Dipterocarpaceae represent a younger element in the New Guinea flora, an element which has been derived from the northwest by way of Celebes and the Philippines. This conclusion was reached by Doctor Diels solely on the indicated botanical relationships of the New Guinea species, and is absolutely in accord with the general conclusions I have drawn regarding the origin of the Philippine flora in relation to the geographic distribution of the Dipterocarpaceae. This apparent derivation of the Papuan Dipterocarpaceae from the northwest, that is, Celebes and the Philippines, may perhaps be interpreted as supporting the idea that in previous geologic epochs a drier climate characterized the lesser Sunda Islands, and perhaps southern Java, which would, of course, inhibit the eastern extension of hygrophytes over this southern route into Celebes. The only possible route under these conditions between western Malaysia and New Guinea would then be through Borneo, the Philippines, Celebes, and the Moluccas.

There are, of course, other than strictly geologic factors to be taken into consideration in discussing the differences between eastern and western Malaysia. As Mr. I. H. Burkill has recently indicated to me, there is the possibility that in past geologic epochs the climate of southern Java and of the lesser Sunda Islands may have been drier than it is to-day; even to-day the climate of Timor and of the lesser Sunda Islands generally is drier than that of other parts of Malaysia. This would have the effect of inhibiting the extension of the dipterocarps and of other plants, as well as animals, that are adapted to humid conditions eastward through the southern part of Malaysia, and this may in part explain the absence of dipterocarps in Timor and the lesser Sunda Islands. We must, however, not overlook the fact that there has also been much destruction of life on some of the smaller islands in this particular region by volcanic eruptions. The swift currents through such narrows as the Lombok

Passage would also greatly restrict the passage of both plants and animals, and it is safe to assume that such swift currents have existed since the Lombok Passage was formed.

In connection with the paucity of Dipterocarpaceae known from eastern Malaysia and the possibility that the number may be increased by further exploration, Diels has already expressed his opinion regarding New Guinea. No species is known from Gilolo, where a few at least are to be expected. Only five are known from all of Celebes, and in view of Doctor S. H. Koorders's extensive botanical explorations in northern Celebes (Minahassa) we can hardly expect many additional species in this part of Celebes. Doctor Koorders collected in Minahassa primarily as a forester for nearly five months, and as a forester he certainly would not have overlooked the economically important dipterocarps; his entire collection from Minahassa in northern Celebes, comprising some 3,500 numbers, presents only a single species of Dipterocarpaceae, *Shorea koordersii* Brandis. It would seem then that we are not justified in expecting numerous additions to the dipterocarp flora of eastern Malaysia as botanical exploration progresses, in spite of the fact that the flora of the entire region is very imperfectly known, although it is about as well known, comparatively speaking, as is that of Sumatra and Borneo.

We have seen then that the dipterocarps are very strongly represented in western Malaysia, that is, "Sunda Land," the Malay Peninsula, Sumatra, Java, and Borneo; very poorly represented in eastern Malaysia, Celebes, the Moluccas, Gilolo, and New Guinea; and fairly well represented in the Philippines, by nine genera and fifty species, the great trees of this family being dominant in the primary forests of our Archipelago at low altitudes. Therefore, it will be seen that the Philippines are intermediate between eastern and western Malaysia in dipterocarp representation.

What is the case in reference to other families of plants? It has been known for over twenty years that the Philippine flora presents strong Celebesian and Moluccan alliances, and as exploration has progressed Papuan, New Caledonian, and Australian elements have become more and more evident. At the same time, there are distinct evidences of definite relationships with western Malaysia or the Sunda Islands, as indicated by the genera of Dipterocarpaceae alone. Of the twelve genera of this family found in the Malay Peninsula and the Sunda Islands nine extend to the Philippines, as against four that extend to eastern

Malaysia. Of these nine *Isoptera* is known only from the Malay Peninsula, Bangka, Borneo, and Mindanao; *Parashorea* is known only from the Malay Peninsula, Sumatra, Borneo, and the Philippines (Luzon to Mindanao) ; and *Pentacme* is known only from the Malay Peninsula and the Philippines (Luzon to Mindanao).

It has long been known that there are striking differences between the floras of eastern and western Malaysia, but it seems that as yet no botanist has made a direct comparison to see wherein the differences lie. The number of species is so great (estimated by me at 45,000 for the entire region, including the Philippines) that I have been obliged to limit my investigations to a larger unit and have selected the genus as the unit. This task has been sufficiently arduous, for the number of genera involved is approximately 3,000.

In comparing the ranges of all genera of flowering plants known from the Malaysian region as between eastern and western Malaysia and the Philippines, eliminating those introduced by man in modern times, we note the following significant results: In western Malaysia we find about three hundred fifty-six genera which are not known from east of Wallace's Line, *but in the Philippines two hundred eighteen, or 61 per cent, of these occur.* In eastern Malaysia we find about two hundred twenty-five genera which do not extend to western Malaysia, *and of these fifty-six, or about 25 per cent, are known from the Philippines.*

We have then in the Philippines numerous genera from western Malaysia that do not occur in eastern Malaysia, and fewer, but at the same time a most striking assemblage, of Celebesian, Moluccan, Papuan, and Australian types that extend to the Philippines but do not reach western Malaysia. There are Australian types in western Malaysia, but few indeed as compared with the same element in the Philippine flora. In general, then, the generic distribution in Malaysia confirms the conclusions that may be drawn from the study of the distribution of the Dipterocarpaceae, namely: That there were certain definite land connections between Borneo and the Philippines over which the western Malaysian elements migrated into the Philippines, including our Dipterocarpaceae, numerous genera of wide Malaysian distribution, and the two hundred eighteen genera that occur in western Malaysia and the Philippines but not in eastern Malaysia. Later these connections were broken, between Mindoro and the Calamian Islands to the north and in the Sulu Archipelago to the south, inhibiting further Bornean migrations into the Archipelago proper but permitting later

Bornean elements to enter the Balabac-Palawan-Calamian group to the north and the Sulu Archipelago and perhaps the Zamboanga Peninsula of Mindanao to the south. It is significant that the ornithologists and zoölogists wish to derive the Palawan avifauna and mammalian fauna wholly or largely from Borneo, and the herpetologists and some entomologists are apparently like minded in reference to their respective groups. Everett [27] claims that there has been no land connection between the Palawan-Calamian group and the Philippines proper since Palawan received its present fauna. Pagenstecher,[28] however, states that, of the two hundred thirty-five species of Lepidoptera that occur in Palawan, one hundred thirty are found in the Philippines proper and one hundred twenty in Borneo, and sixty-five are common to the three regions. In respect to the lepidopterous fauna Palawan is evidently as much Philippine as it is Bornean. The Palawan flora is definitely about as much Philippine as it is Bornean, and the Bornean elements in its flora are relatively very weak when compared with the manifestly very strong Bornean zoölogical elements found there.

We have already seen that direct land connections between Borneo and Celebes have not existed since early Tertiary. There were probably indirect connections via eastern Java and Celebes through what are now intervening islands, but these connections could not have been very extensive nor very long continued. There were definite connections between Mindanao and Celebes via the Sangi Islands, and possibly between Mindanao and Gilolo and, in turn, with New Guinea via Talaut Island, and these connections existed some time during the Tertiary; probably they existed at different times, having been more or less intermittent, for depressions and elevations have been characteristic of the entire region throughout the Tertiary and Quarternary ages. The Celebes-Mindanao connections were not necessarily in existence at the same time that a land bridge existed between Borneo and Mindanao. The evidence seems to be that the connections between the Philippines and Borneo were earlier, more extensive, and longer continued than were the connections between Mindanao and the islands to the south and east. Thus the dominant dipterocarps were permitted to enter

[27] Everett, A. H., Remarks on the zoögeographical relationships of the island of Palawan and some adjacent islands, Proc. Zool. Soc. London (1889) 220–228, map.

[28] Pagenstecher, A., Die geographische Verbreitung der Schmetterlinge (1909) 1–451 (p. 237).

the Philippines, some with and some after (see p. 8) the arrival of numerous other western Malaysian types; at certain times a limited number of Philippine types of dipterocarps and other groups were enabled to migrate southward into Celebes, Gilolo, the Moluccas, and New Guinea; and at the same time numerous generic types from these regions, together with a rather strong Australian element, were enabled to reach the Philippines.

The explanation of the fundamental differences in the geologic history of eastern and western Malaysia, so clearly stated by Molengraaff, enables us to give the reasons for the evident differences between the floras and faunas of these two regions, and to explain why the Philippine flora and fauna show definite relationships with those of both eastern and western Malaysia; why the Australian element is so much stronger in the Philippine flora than it is in that of western Malaysia; and why the dipterocarps and numerous other Malaysian types and, in general, the Australian elements failed to reach Formosa, although many of them extend to northern Luzon and some even into the Babuyan and Batan Islands. Formosa is separated from the Philippines by a very deep channel or trough, similar to those discussed by Molengraaff as characteristic of eastern Malaysia. There is no evidence of land connection between Luzon and Formosa since early Tertiary times.

I have already stated (p. 25) that the zoölogists generally derive the Palawan-Calamian fauna from Borneo, some claiming that no connection can have existed between this group and the Philippines proper since Palawan received its present fauna. It is of some interest here to examine the Philippine distribution of our dipterocarps. The larger islands characterized by the presence of numerous species are Luzon, Mindoro, Samar, Leyte, Negros, Panay, Mindanao, and Balabac. But four species are known from the Balabac-Palawan-Calamian group and but one from the Sulu Archipelago. Thirty-nine of our fifty known species, or 78 per cent, are endemic, the remainder occurring in various parts of western Malaysia. Most of our endemic as well as our extra-Philippine forms are of wide distribution within the Archipelago, extending from northern Luzon to Mindanao and Basilan. These are, of course, some local species.

Of our nonendemic dipterocarps *Dipterocarpus gracilis* Blume is recorded from Luzon, Mindoro, and Java; *D. grandiflorus* Blanco, from Luzon to Mindanao, Palawan, Borneo, Bangka, and the Malay Peninsula; *D. hasseltii* Blume, from Luzon to

Mindanao, Java, Sumatra, and the Malay Peninsula; *D. trinervis* Blume, from Palawan and Java; *Anisoptera curtisii* Dyer, from Luzon to Negros, Borneo, and the Malay Peninsula; *Hopea pierrei* Hance, from Luzon to Mindanao, Borneo, Malay Peninsula, and Indo-China; *Shorea balangeran* Dyer, from Luzon to Mindanao, Borneo, Bangka, and Billiton; *S. eximia* Scheff., from Luzon to Mindanao, Borneo, Sumatra, and the Malay Peninsula; *S. palosapis* Merr., from Luzon to Mindanao and Borneo; *S. teysmanniana* Dyer, from Luzon to Mindanao and Bangka; and *Isoptera borneensis* Scheff., from the Zamboanga Peninsula of Mindanao, Borneo, Bangka, and the Malay Peninsula.

Only one dipterocarp, a species of *Hopea,* is known from the Sulu Archipelago, this occurring on Tawitawi Island. This might be interpreted to mean that our dipterocarps could not have come over the Sulu bridge. There are a few islands in the Sulu Archipelago on which dipterocarps might be expected, notably Jolo and Tawitawi, but on Jolo the primary forest has practically all been destroyed by man. The Sulu Archipelago has moreover been raised and depressed, not once but several times, so that it is only reasonable to suppose that its vegetation has at times been partly or entirely destroyed by natural causes.

In Palawan we find but five recorded species of dipterocarps, although future exploration may increase this number. They are *Dipterocarpus vernicifluus* Blanco, *D. grandiflorus* Blanco, *D. trinervis* Blume, *Vatica obtusifolia* Elm., and *V. blancoana* Elm. Of these the first two occur throughout the Philippines from northern Luzon to Mindanao, the first being supposedly endemic, although possibly it should be reduced to *D. gracilis* Blume, of Java; the second extends to Borneo, Bangka, and the Malay Peninsula. *Dipterocarpus trinervis* Blume is known only from Palawan and Java; *Vatica blancoana* Elm., only from Palawan and Mindanao; and *V. obtusifolia* Elm. is confined to Palawan. In Palawan we know of no representatives of the genera *Anisoptera, Balanocarpus, Hopea, Isoptera, Parashorea, Pentacme,* and *Shorea;* yet, all occur in the Philippines, many being dominant, and all occur in western Malaysia. Can, then, our dipterocarps have come in over the Palawan bridge? The question cannot be answered definitely, but it is very clear that most of our forms must have come in over one or both of these Borneo-Philippine bridges, the Sulu to the south and the Palawan to the north, on account of their paucity in the islands to the south of the Philippines and in Java; they could scarcely have come in from Java via Celebes. It is possible, even probable,

that Palawan has been submerged and most or all of its vegetation destroyed since the existence of its earlier connection with the Philippines by which our dipterocarps and numerous other western Malaysian types in all probability reached the Philippines (see p. 8); whatever the case, the Palawan-Calamian group has been severed from the Philippines proper by the Mindoro Strait since Pleistocene times, and received much of its present fauna from Borneo in the middle or late Pleistocene. At the same time it has also received certain very definite Bornean elements of its flora that have failed to reach the Philippines proper, although its flora is by no means strictly Bornean, but presents approximately as many Philippine elements as it does Bornean ones. In other words, its flora has been derived in part from Borneo and in part from the Philippines proper.

There must have been extensive and especially prolonged connections between Borneo and the Philippines, but there is no evidence that these connections were more than the Sulu and Palawan isthmuses. It is highly improbable, although not impossible, that some of our western Malaysian elements came in from eastern Java over the Java-Celebes and the Celebes-Mindanao bridges; but, had there been any extensive migrations over this route, we would naturally expect to find a much greater mingling of Australian and Asiatic types in Celebes than actually exists, with corresponding Australian types in Java. In the Mindoro flora we find certain western Malaysian types that extend from Borneo through Palawan to Mindoro but do not occur farther east. We cannot ignore the fact that our one large indigenous mammal, the timarao, is confined to Mindoro, and that it must have been derived from Asiatic stock; it unquestionably reached Mindoro over the Palawan bridge. It is currently stated that the timarao is most closely allied to the anoa of Celebes, but this seems not to be the case, as Doctor Hollister informs me that the timarao is not congeneric with the anoa but is congeneric with a form that occurs in Borneo.

CONCLUSIONS

1. From the geologic and hydrographic data so admirably presented by Molengraaff, it is perfectly evident that the geologic history of eastern Malaysia has been radically different from that of western Malaysia. The area approximately delimited by the Asiatic continental shelf, which carries upon it all of the Sunda Islands, was a continental area in the Pleistocene and probably

at times during the preceding geologic periods; similarly, the area delimited by the Australian continental shelf, carrying upon it New Guinea, was also a continental area. Interposed between these two stable continental regions, that is, from the Lombok Passage and the Macassar Strait extending to the eastward as far as the west end of New Guinea and northward through most of the Philippine Archipelago, we find a region in sharp contrast to the two above-mentioned stable continental areas. The entire intermediate region has been unstable, subject to elevations and depressions, from at least the early Pleistocene to the Recent and is still orogenetically active and, as a result, still unstable. In other words, archipelagic rather than continental conditions have persisted in this vast region since the early Pleistocene, and probably earlier.

2. Wallace's Line, so named by Huxley, separating the fauna of eastern and western Malaysia, was located by Wallace through the Macassar Strait and extended southward through the Lombok Passage between Bali and Lombok. It is essentially the western boundary of the insular unstable area and, as a corollary, the eastern boundary of the ancient stable continental area. Wallace's Line is a striking faunal and floral boundary (although not an absolutely separating one) when the distribution of all groups of animals and plants is taken into consideration. It is essentially based on fundamental geologic differences between Sunda Land and the region to the east. West of Wallace's Line animals and plants have been able to migrate from one part of the previously existing continental area to other parts, subject only to those limitations that are found in continental areas. East of this line all intermigrations of Australian and Asiatic types of animals and plants have been interrupted by the constant archipelagic conditions existing in the region under discussion and, at times, all or most intermigrations have been inhibited by impassable barriers in the form of separating arms of the sea. As between the various islands in this vast region and the previously existing continental areas to the west and southeast, land connections have never been more than narrow isthmuses. The evidence is that this fundamental dividing line between eastern and western Malaysia did not extend to the east between Celebes and Mindanao, as originally placed by Wallace, but extended northward through the Sibutu Passage and the Sulu Sea to the Mindoro Strait and thence northward and then eastward into the Pacific Ocean between Formosa and the Batan Islands. There have been no direct land connections between

Celebes and Borneo across the Macassar Strait since the early Tertiary, but indirect connections have existed through Borneo and Celebes via the Sulu Archipelago, Mindanao, and the Sangi Islands, and probably also between eastern Java, Bali, Lombok, and other smaller islands and southwestern Celebes. The southward extension of Wallace's Line through the Lombok Passage, as well as its northern extension through the Sibutu Passage, the Sulu Sea, and the Mindoro Strait has not been as strongly marked nor as persistent as the Macassar Strait, and hence has not been as efficient a barrier to the passage of animals and plants as has the narrow strait between Celebes and Borneo.

3. Weber's Line, so named by Pelseneer, is apparently the approximate eastern boundary of the unstable area, separating the insular region from the continental and stable areas now delimited by the continental shelf surrounding and uniting New Guinea and Australia. Geologically, this is ranked by Molengraaff as the most important dividing line in Malaysia. Biologically, it apparently ranks with Wallace's Line as an important dividing line between the Moluccan-Timor regions and Australia, quite as Wallace's Line separates western from eastern Malaysia. This paper then is essentially a re-interpretation of Wallace's Line, botanically tested, as well as a test of Weber's Line.

4. The Dipterocarpaceae present eleven genera and one hundred thirty-five species in the Eastern Peninsula, eleven genera and one hundred forty-four species in the Sunda Islands, nine genera and fifty species in the Philippines, and only four genera and fourteen species in the entire group from Celebes to New Guinea southward to Lombok and Timor. A study of the Malaysian distribution of all the Malaysian genera of flowering plants shows about three hundred fifty-six genera in western Malaysia that are unrecorded from eastern Malaysia, of which two hundred eighteen, or 61 per cent, reach the Philippines; and about two hundred twenty-five genera in eastern Malaysia that do not reach western Malaysia, of which fifty-six, or about 25 per cent, reach the Philippines. The Philippine flora thus presents strong relationships with the floras of both Papua and Sunda Land. The evidence from the geographic distribution of the Dipterocarpaceae conforms entirely with the general generic distribution of all groups of flowering plants in the whole Malaysian region, indicating previously existing and rather long continued land connection between the Philippines and Borneo via the Sulu Archipelago to the south and the

Balabac-Palawan-Calamian group to the north. This connection was apparently earlier, more pronounced, and longer continued than the connections between Mindanao and Celebes, Gilolo, the Moluccas, and New Guinea to the south and east.

5. The dipterocarps were apparently dominant in the Philippines as early as the Pliocene, and probably earlier. From the biologic characters of the group it is evident that when they reached the Philippines the entire region was a forested one.

6. After the earlier connections with Borneo were broken there were later definite connections between Borneo and, apparently, the Zamboanga Peninsula (southwestern Mindanao was during a portion of Pleistocene time a separate island) via the Sulu group to the south, and between the Balabac-Palawan-Calamian group to the north as far as the Mindoro Strait, allowing later definite migrations into these regions of Bornean types of animals and plants which could not reach the Philippines proper.

7. The intermittent isthmuses connecting Mindanao with the islands to the south and southeast have permitted intermigrations here, and Celebesian, Moluccan, Papuan, and a distinctly important series of Australian types have thus traveled the longer distance, many to northern Luzon and even into the Babuyan Islands, rather than the shorter distance into western Malaysia, not having been able to cross the narrow but long-persistent Macassar Strait.

8. The entire absence of the dipterocarps in Formosa, the slight evidences of biological relationships between Luzon and Formosa, and the fact that, with very few exceptions, none of the Australian and eastern Malaysian types in the Philippine flora reach Formosa indicate clearly that there have been no land connections here since early Tertiary times.

9. The distribution of birds, reptiles, fresh-water fishes, mammals, and many groups of insects as between eastern and western Malaysia in general conforms to the distribution of the plants. Thus, very many Asiatic types extend as far as the Macassar Strait and, while some cross it, they appear in rapidly dwindling numbers as we go eastward to New Guinea. Likewise, Australian types decrease with as great or greater rapidity as we go westward from New Guinea. In the Philippines we find distinct alliances in the mammals and birds with both eastern and western Malaysia, corresponding to similar alliances in the flora. This likewise holds true for the reptiles and insects, while of the fresh-water cyprinoids twenty-seven

are known from the Philippines, in contrast to one or, at most, two that occur east of Wallace's Line and live only in Lombok and Sumbawa, again indicating more-pronounced and longer-continued land connections with the islands to the southwest than with those to the south and southeast.

10. No single line can be drawn, anywhere in Malaysia, that is a true biogeographic boundary. With two stable areas delimited by the Asiatic and Australian continental shelves and an intermediate insular unstable region between these two stable areas there must of necessity be an eastern and a western boundary of the unstable area where it impinges on the stable areas to the east and to the west. The western limits of the unstable area are approximately defined by Wallace's Line, and the eastern limits by Weber's Line. These two biogeographic boundaries are primarily due to fundamental geologic conditions. They may have approximately equal values but a much more intensive biologic exploration of the entire region will be required before the essential data necessary to evaluate them become available. Wallace's Line cannot be abandoned in favor of Weber's Line nor vice versa.

11. In Malaysia as a whole we find apparently two great centers of origin and distribution, Sunda Land to the west and, as Miss Gibbs [29] has already pointed out, New Guinea to the east. To a large degree the fauna and flora of the islands in the intermediate unstable area between Wallace's and Weber's Lines are made up of infiltrations from the regions to the west and to the east. From both regions there have been strong migrations into the Philippines, one through the Sulu and Palawan bridges from Sunda Land via Borneo, the other from Papua through the Moluccas and Celebes.

[29] Gibbs, L. S., Dutch N. W. New Guinea. A contribution to the phytogeography and flora of the Arfak Mountains (1917) 1–126 (p. 39).

ILLUSTRATIONS

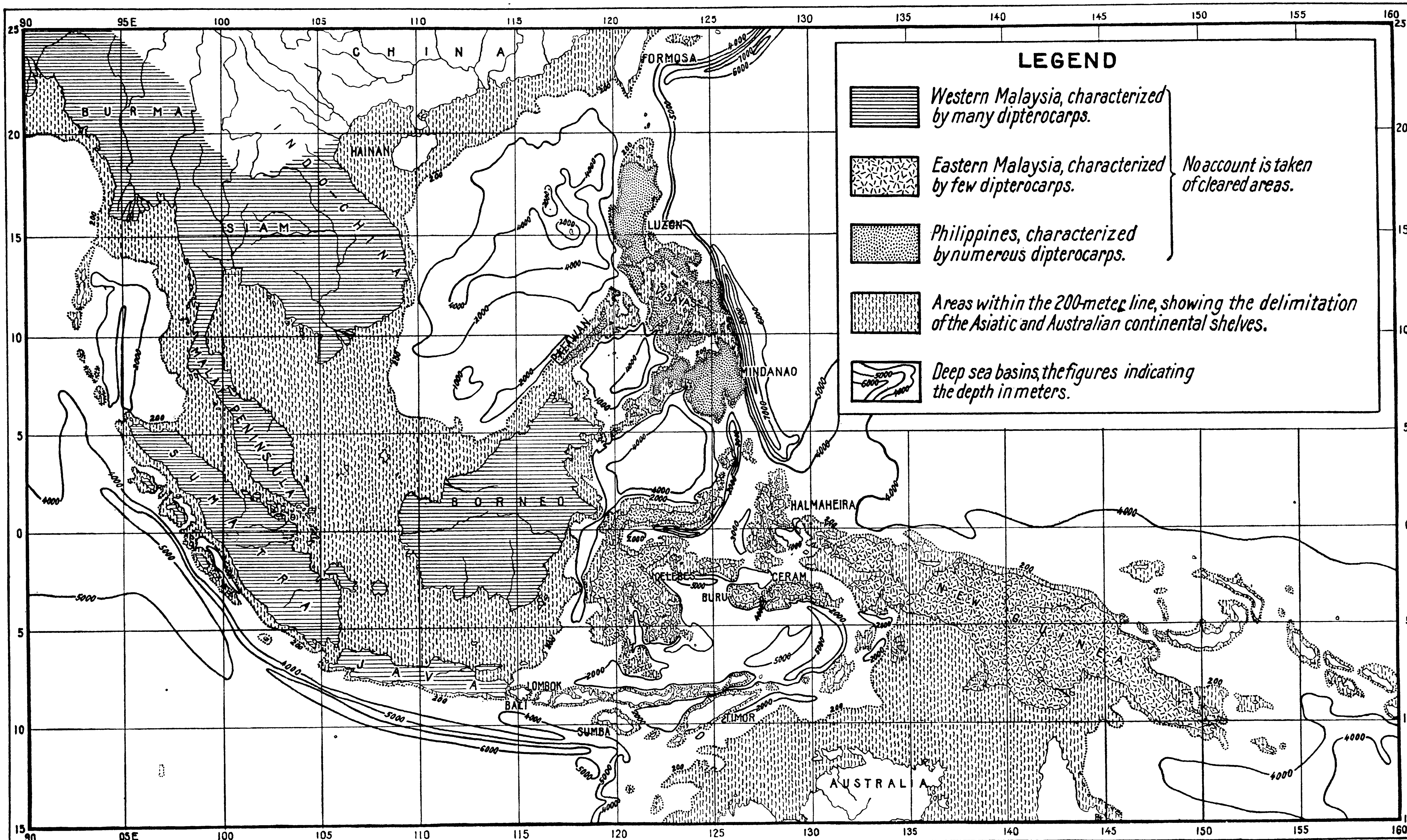

PLATE 1. THE MALAYSIAN REGION, SHOWING THE ASIATIC AND AUSTRALIAN CONTINENTAL SHELVES AND THE ASSOCIATED DEEPS.

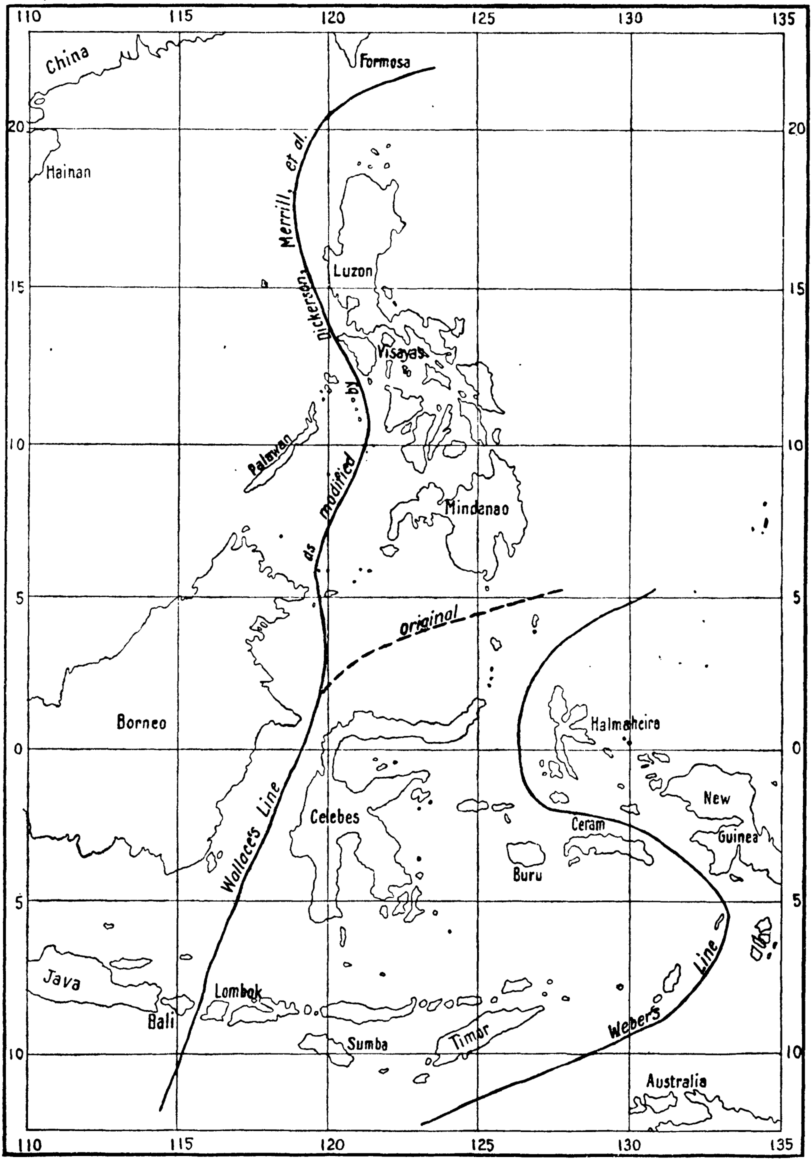

PLATE 2. THE UNSTABLE AREA BETWEEN THE SUNDA ISLANDS AND AUSTRALIA, SHOWING THE POSITIONS OF WALLACE'S AND WEBER'S LINES.

PLATE 3.

PLATE 4.

PLATE 5.

PLATE 6.

PLATE 7.

Fig. 1.

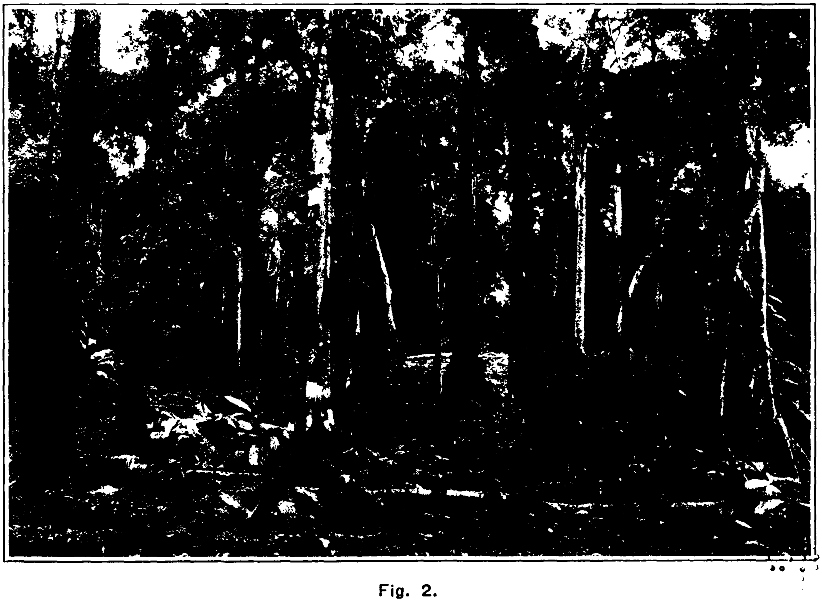

Fig. 2.

PLATE 8.

OBSERVATIONS ON THE LIFE HISTORY OF THE HORSE OXYURID (OXYURIS EQUI)

By BENJAMIN SCHWARTZ
Of the University of the Philippines

ONE PLATE AND TWO TEXT FIGURES

SCOPE OF WORK

The object of this paper is to record observations that have a bearing on the life history of *Oxyuris equi*, a nematode of common occurrence in the colon, cæcum, and rectum of horses in the Philippine Islands. In view of the fact that several references to the morphology and biology of *Oxyuris equi* are not obtainable in the Philippine Islands the work of former investigators that may have a bearing on the life history of this parasite cannot be reviewed fully in this paper.

THE EGG

The egg of *Oxyuris equi* is elliptical in shape, slightly asymmetrical, and is enveloped in a firm cuticle having a double contour and also an operculum at one end, the latter resembling that of trematode eggs. Numerous observations on the hatching of the eggs in vitro have shown that the larva invariably escapes from the eggshell through the opening that is covered by the operculum. Empty eggshells that were recovered from the intestines of guinea pigs that were fed eggs of *Oxyuris equi* almost invariably lacked the operculum. In eggs that hatched in vitro the operculum frequently adhered to the eggshell and in several cases still retained its normal position. Such shells were intact, however, showing conclusively that the larvæ must have escaped through the opercular end and that the operculum, after being lifted as a result of the movements of the embryo against its inner surface, regained its normal position following emergence of the larva from the shell.

Measurements of numerous eggs have shown considerable variation in size, the range of variation being from about 74 to 100 μ in length by from 38 to 47 μ in width. In Table 1 are given the records of size of twenty-three eggs selected at random.

TABLE 1.—*Showing variation in size of eggs of Oxyuris equi.*

Egg No.	Length.	Width.	Egg No.	Length.	Width.
	μ	μ		μ	μ
1	82	41	13	84	46
2	95	42	14	91	46
3	89	44	15	73	40
4	88	46	16	91	38
5	84	42	17	91	38
6	91	46	18	76	42
7	86	46	19	89	46
8	99	46	20	91	46
9	91	46	21	85	40
10	87	46	22	91	42
11	91	42	23	91	46
12	89	40			

Eggs considerably smaller than those recorded in Table 1 are occasionally found, but they are rare and probably abnormal since no miniature embryonated eggs have been observed in any of my cultures.

OVIPOSITION

Oviposition has been repeatedly observed in vitro, and in many cases certain specimens that were kept overnight in the laboratory in beakers containing physiological salt solution yielded many eggs that were found floating on the surface of the liquid, the eggs being agglutinated by a gluey substance that is insoluble in water and in physiological salt solution (fig. 1).

So far as my observations go, long-tailed forms of *Oxyuris equi* (*mastigoides* type) almost invariably oviposit in vitro, discharging practically the entire egg content, whereas short-tailed forms (*curvula* type) seldom oviposit under similar conditions; but few eggs are discharged from these ovipositing forms, the bulk of the eggs being retained in the uteri. In this connection it may be mentioned that long-tailed forms of *Oxyuris equi* are comparatively scarce in native horses and that they are usually located in the cæcum, whereas short-tailed forms are usually located in the colon, in which organ they were frequently found in large numbers (fig. 2).

Oviposition in *Oxyuris equi* is preceded by prolonged contractions of the uterus whose movements may be characterized as peristaltic. Uterine contractions are practically the only evidence of vitality of horse oxyurids, since I have never observed the characteristic nematoid movements in these parasites, and

according to my experience they cannot be artificially stimulated to activity by heat. The worms appear rigid and without any visible sign of activity, except occasional feeble movements of the tail, not only after they have been removed from the host but also when they are encountered in their normal location within a short time after the death of the host animal. Other intestinal as well as a stomach-inhabiting nematode removed at the same time from the host exhibited the usual lively nematoid movements of contraction, expansion, and of twisting

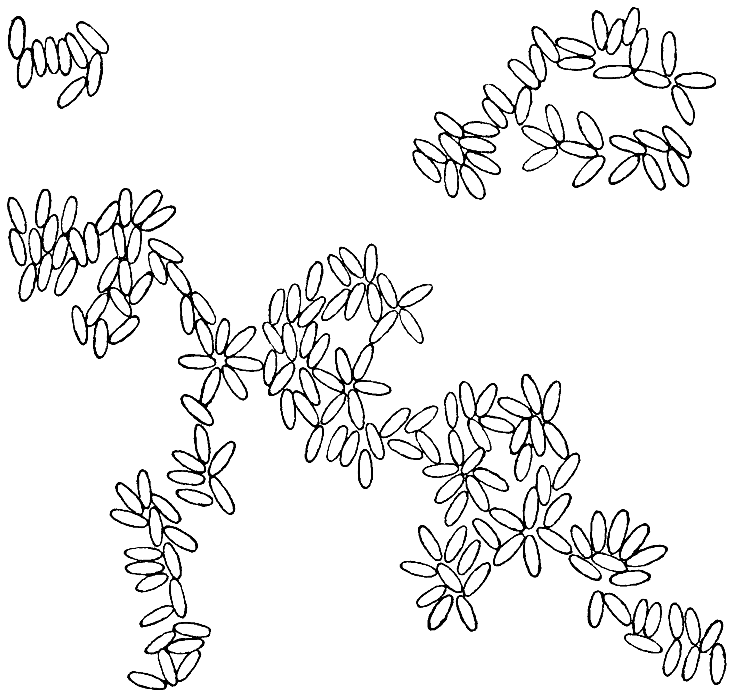

FIG. 1. Agglutinated eggs of *Oxyuris equi.* Free-hand sketch from cover-glass preparation.

the body into various positions. The only test of the vitality of *Oxyuris equi* is close examination of the worms for evidence of uterine movements, which are visible to the naked eye because the internal organs can be seem through the transparent cuticle.

During the uterine contractions the eggs are pushed forward and backward with the wavelike movements of the uterus and this process may continue for several hours before oviposition takes place. The eggs are usually liberated with considerable force, often with explosive violence, and stream out through the vaginal opening in stringy masses which flatten out in thin

layers on the surface of the fluid medium, where they remain floating like frog spawn. The gluey invisible substance that holds the eggs together does not deteriorate after prolonged exposure to air. In view of this gluey investment, the eggs adhere tenaciously to any object with which they come in contact. If the vessel, containing eggs on the surface of a liquid medium, is tilted the eggs adhere to its sides and cannot be washed off or pried loose by violent agitation of the contents of the vessel. When sucked up in a glass pipette or stirred with a glass rod the eggs adhere to the surface of the glass with equal tenacity. In liquid media normally oviposited eggs float, and only isolated eggs sink to the bottom.

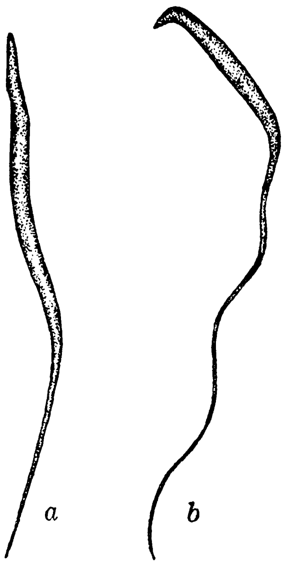

FIG. 2. *a*, *Oxyuris equi* (*curvula* type), short-tailed female; *b*, *Oxyuris equi* (*mastigoides* type), long-tailed female. Natural size.

Following the discharge of eggs from the uterus, the females of *Oxyuris equi* shrink in size, the cuticle becomes wrinkled in consequence of the shrinkage, and the worms exhibit no further signs of vitality. Egg laying thus appears to be the last function performed by the females of *Oxyuris equi*, death probably ensuing after the act of oviposition has been completed. Although this conclusion is based upon observations in vitro, it is highly probable that the same course of events ensues under conditions that are normal for this parasite, because adult females of *Oxyuris equi* are always full of eggs, indicating that they discharge their eggs all at once; possibly they may oviposit several times in rapid succession, and those that have discharged their eggs may be rapidly eliminated from the digestive tract. The scarcity or even total absence of males in hosts harboring numerous females of *Oxyuris equi* warrants the view that the discharge of the sexual elements is the final function in the life of the males, the latter probably passing out of the host shortly after copulation.

Numerous attempts were made to induce the discharge of eggs by short-tailed females, but these attempts were only partially successful, resulting either in the liberation of few eggs or in a sudden eversion of the uteri and liberation of the eggs with explosive violence. This occurred in water and in phy-

siological salt solution. The following artificial stimuli were used to bring about oviposition in vitro. The water or salt-solution medium was acidulated and rendered slightly alkaline; the medium was gradually heated by addition of hot liquids (hot water and hot physiological salt solution being added to the respective media) ; the worms were transferred from water to salt solution and vice versa; the worms were transferred suddenly from a cold medium to a warm medium. The results obtained in these attempts were as follows:

Specimens that exhibited no uterine movements could not be stimulated to uterine contractions by any method; these forms were probably nonviable. Females that exhibited uterine contractions generally reacted positively to artificial stimuli. As a result of transferring the worms from water to salt solution and vice versa, the uterine contractions were generally accelerated. Gradually heating the medium in which the worms were contained and the sudden transfer of the worms from a cold to a warm medium had a very marked influence on the movements of the uterus which became intensified; these intense contractions continued after the liquid had cooled and resulted in an explosive discharge of eggs with eversion of the uterus through the vaginal opening.

Several years ago I made similar observations on oviposition in a species of *Oxyuris* from a chimpanzee from the National Zoölogical Park at Washington, D. C. Numerous specimens, all females, were obtained from the monkey following the administration of an enema. The parasites were alive and when viewed through a binocular microscope marked movements of the uteri were observed, these movements terminating with the discharge of stringy masses of eggs. In a second lot of worms obtained from the same monkey, the parasites were transferred to warm physiological salt solution, which resulted in rapid liberation of the eggs. Following the expulsion of the eggs the worms became quiescent.

Seurat(8) records similar observations on egg laying in a species of oxyurid in which oviposition was preceded by uterine contractions which resulted in the liberation of the eggs in long strings.

DEVELOPMENT OF EGGS

The usual procedure that is followed in order to obtain large numbers of eggs of a given species of nematode for life-history studies consists in securing mature females and chopping them

up finely with a pair of scissors, thus liberating the eggs, which may be planted on a charcoal and fæces mixture, in water, or in any other suitable medium. This procedure was found to be inapplicable to *Oxyuris equi,* because numerous attempts to bring about the development of the eggs of this parasite by planting artificially liberated eggs in water, in physiological salt solution, on charcoal and fæces mixtures, in 2 per cent as well as in weaker dilutions of formalin, were invariably unsuccessful. The eggs underwent degenerative changes in all media except formalin solution, in which liquid they remained intact for some time.

Artificially liberated eggs of *Oxyuris equi,* secured as a result of chopping up the worms, differ from normally discharged eggs in that the egg substance has a finely granular appearance, fills almost completely the interior of the shell, and shows no trace of segmentation. In the opercular end of these eggs one or two spherical areas less dense than the remaining egg substance are present (Plate 1, fig. 1). In eggs that are discharged from the uterus the egg substance appears as a compact coarsely granular mass, more or less spherical in shape, and filling only the central portion of the interior of the shell, leaving empty spaces at both poles. Moreover, the egg substance shows decided segmentation (Plate 1, fig. 2).

In a number of cases I examined eggs shortly after they were oviposited following the application of artificial stimuli and found them to be segmented, thus showing that segmentation occurs rapidly, probably while the eggs are still in the uterus.

The failure of eggs, artificially liberated by chopping up female oxyurids, to develop and the rapidity with which oviposited eggs develop in vitro indicate that some profound change occurs in the eggs shortly before they are laid. Whether this change is that of fertilization, or whether it is due to the early cleavage stages that probably occur before oviposition, has not been determined.

Another respect in which artificially liberated eggs differ from those that are normally expelled by the female parasites is that the former sink to the bottom of liquid containers in one solid mass that can be broken up only with considerable difficulty, owing to their being firmly agglutinated. When broken up into small thin masses the latter may come to the surface. Normally discharged eggs float almost invariably on the surface of water and salt solution. Some eggs that are liberated from short-tailed females, as a result of the application of arti-

ficial stimuli that are described elsewhere in this paper, are segmented and develop normally, whereas others are nonsegmented and deteriorate. Eggs that are liberated under such conditions in large masses due to the eversion of the uterus are largely nonsegmented and do not show any developmental changes in vitro. Eggs that are normally deposited by short-tailed females develop normally.

Development of the eggs proceeds rapidly on the surface of liquid media and it takes place just as rapidly if the eggs are placed on dry glass slides and not protected in any way from loss of moisture content. Development also proceeds normally in eggs that adhere to the sides of glass beakers at a considerable distance above the surface of liquid media.

In view of the gluey investment of the eggs they retain a somewhat moist appearance for several days even though they are kept in a dry place and continue their normal development. The gluey coating probably makes possible the retention of sufficient moisture for development. No differences in the rapidity of development of eggs kept in dry and moist media, respectively, have been observed; therefore, it may be concluded that environmental moisture is not an essential factor in the development of eggs of *Oxyuris equi*, the necessary moisture being contained in the egg and protected against evaporation by the gluey substance that surrounds it.

While free access of moisture does not appear a necessary environmental factor in the development of the eggs of *Oxyuris equi*, free access of oxygen is essential, since development was not observed in eggs that sank to the bottom of liquid-containing vessels. In glass beakers, containing floating eggs on the surface of water or physiological salt solution, numerous isolated eggs were usually found at the bottom, and these eggs after many days showed no developmental changes beyond those shown in Plate 1, figs. 2 and 3. Meanwhile the eggs floating on the surface developed rapidly and in four days contained active embryos. That nondeveloping eggs at the bottom of liquid-containing vessels were viable and capable of complete development was shown by the fact that when these eggs were transferred to glass slides, and the moisture was allowed to evaporate, they continued their development and attained the embryonated stage. Furthermore, when the liquid in glass dishes containing nondeveloping eggs at the bottom was allowed to evaporate, development was resumed as soon as the eggs were exposed to oxygen, and motile embryos were formed. It is evident, there-

fore, that oxygen is an essential factor in the development of the egg of *Oxyuris equi*.

Within from twenty-four to thirty-six hours after oviposition individual blastomeres could be made out only with difficulty, and in many instances could no longer be distinguished, because the outline of the embryo became evident (Plate 1, fig. 4). Within from forty-eight to sixty hours after oviposition development had proceeded to the stages shown in Plate 1, figs. 5 and 6. The embryos showed a definite orientation in the shell, the knoblike constricted portion being located at the opercular end. Cultures of eggs seventy-two hours old showed a sausage-shaped embryo (Plate 1, fig. 7) which exhibited sluggish movements. Ninety-six-hour cultures showed embryonated eggs, the embryos exhibiting lively and continuous movements within the shells.

LONGEVITY OF EMBRYONATED EGGS

Although the eggs of *Oxyuris equi* offer considerable resistance to lack of moisture and to absence of oxygen, and although the embryonated eggs retain their vitality for some time even though they are kept dry until the egg masses lose their glistening appearance, prolonged subjection of the eggs to unfavorable conditions results in their gradual loss of vitality and, ultimately, in death. Newly formed embryos were active within the shell despite the fact that they were kept in a dry place. After several days' drying the embryos were inactive in the shell but resumed their activities rapidly when moistened. At this stage hatching readily occurred in vitro. After two or three weeks' drying the larvæ appeared sluggish when moistened, and many showed no movement within the shell. Such eggs were still viable, because when they were fed to guinea pigs they hatched in the small intestine. Embryonated eggs that were kept dry on slides for about six weeks appeared wrinkled within their shells and, although but few had undergone pronounced degeneration, the intact forms showed no movement when moistened, were paler in appearance than normal larvæ, and failed to respond to heat stimulation. Larvæ kept in a moist beaker for a similar period showed more-pronounced symptoms of degeneration. It is thus evident that the embryonated eggs of *Oxyuris equi,* though resistant to unfavorable conditions for a short time after the formation of the embryo, succumb to environmental conditions after several weeks.

HATCHING

Hatching was observed in vitro in eggs five days after oviposition and one day after the actively motile embryonated stage had been reached. As has already been stated, the embryos escape through the opening in the shell that is covered by the operculum. The latter is probably lifted by the continuous and violent movements of the embryo and frequently drops off entirely, leaving the opening unguarded. I occasionally observed embryonated eggs without an operculum before the larva had even begun to emerge from the shell.

Hatching was seldom observed in eggs that were kept dry on glass slides. Moistening the eggs with water or salt solution usually resulted in hatching, the percentage of hatching eggs varying considerably in different preparations. As a rule relatively few hatching eggs were observed in cover-glass preparations, but in several instances over 50 per cent of the eggs in such preparations hatched. The larva emerges from the shell either head first or tail first, and some forms appear to experience considerable difficulty in wriggling out of the shell. A hatching form in which part of the larva is outside of the shell and the remaining part is still within the shell is shown in Plate 1, fig. 11. As the egg opening is too small to enable the worm to wriggle out easily, it is seen to be constricted a little above the point of insertion in the shell opening, that portion just having slipped through.

I have frequently observed a similar condition in the hatching of certain Strongylidæ, and in these forms I observed a constriction at the point of insertion in the ruptured portion of the shell and a streaming movement of the granular larval substance from the portion of the worm that was still inclosed in the shell to that outside of the shell, thus rendering the former more compressible and making it possible for the larva to pull itself through a narrow opening.

That hatching of *Oxyuris equi* in vitro is purely accidental is evident from the fact that larvæ which emerge from the eggshells into water burst, owing to excessive absorption of the fluid, thus showing conclusively that the larvæ are not destined to a free-living existence. Larvæ that emerge from their eggshells into physiological salt solution do not become plasmoptized, but move about rather sluggishly. No signs of molting in vitro have been detected in these larvæ.

In experimental animals, hatching occurs in the small intestine, as will be shown presently, and the empty eggshells are nearly always without the operculum. The larvæ appear coarsely granular, and the granules obscure the internal organs.

FEEDING EXPERIMENTS

Many attempts were made to bring about artificial infection of guinea pigs with *Oxyuris equi* with a view of determining the behavior of the larvæ in these animals, with special reference to their possible migration through various organs comparable to the migrations of *Ascaris* larvæ. *Oxyuris equi* eggs cannot be sucked up in pipettes for purposes of feeding them to animals, because they stick to the surface of the glass. After several trials the following method was selected as being the most suitable for the purpose. Beakers containing eggs on the surface of liquid media were tilted, thus causing the eggs to adhere to the sides of the vessel. In an hour or two, the eggs were sufficiently dry and were scraped off with a knife and placed in small gelatine capsules which were forced down the œsophagus of the guinea pigs.

Guinea pigs were killed within eighteen, twenty-four, and forty-eight hours after feeding them eggs, as well as after longer intervals, and various portions of the alimentary canal were examined for the detection of larvæ but none were found. Numerous press preparations of the liver, lungs, and other organs, as well as of the blood, also yielded negative results. That the larvæ hatched in these guinea pigs was evident from the fact that empty eggshells which had lost their opercula were found in the fæces of these animals. In the earlier feeding experiments the eggshells were overlooked because the fæcal sediment alone was examined. The shells are absent in the sediment but float on the surface of the fæcal emulsions.

Guinea pigs killed within an hour or two after they had been fed eggs of *Oxyuris equi* contained nonhatched eggs in the stomach, and nonhatched eggs, free larvæ, and empty eggshells in the intestine. The embryonated eggs in the stomach exhibited no movements. In view of the fact that larvæ readily emerge from the shells in vitro, their failure to hatch in the stomach is probably due to a paralyzing effect of the stomach environment on their movements, thus preventing their emergence from the shell.

Seurat(8) quotes Heller (1913) who states that the pinworm of man, *Enterobius* (*Oxyuris*) *vermicularis*, hatches in the

small intestine where it molts twice. Cobb,(1) on the other hand, found that *Enterobius vermicularis* hatched in the human stomach when capsules containing these eggs were swallowed. Cobb states that the capsules were not dissolved and that a considerable amount of gastric fluid entered them. It is possible, of course, that the larvæ in Cobb's experiments emerged from the shells before the gastric fluid entered the capsules.

In view of the rapid disappearance of the larvæ from guinea pigs, no observations on molting were made. Repeated fæcal examinations of guinea pigs that were fed *Oxyuris* eggs failed to reveal any larvæ, and it may be taken for granted that these were digested in the intestines of these animals.

Whether the failure to find larvæ in the lungs and liver of guinea pigs that were fed eggs of *Oxyuris equi* may be accepted as conclusive proof that migrations to these organs do not occur in the course of the life cycle of these parasites is impossible to determine definitely from the data at hand. It is probable, however, that such migrations do not occur in the life history of *Oxyuris equi,* development being simple and direct following ingestion of embryonated eggs.

Following the discovery of the migrations of the larvæ of various Ascaridæ, attempts were made by various investigators to discover migrating larvæ in the life history of more or less common nematodes, but these attempts have been in the main unsuccessful. Thus Füllerborn(2) failed to observe migrations of larvæ of *Trichuris trichiura,* a nematode parasitic in the lower portion of the digestive tract of man, whose morphological affinities with *Trichinella spiralis,* a nematode whose larvæ invade the blood stream, warranted the expectation that a migration of larvæ would probably occur. Füllerborn observed, contrary to his expectations, the beginning of development of these larvæ in the cæcum of rabbits and guinea pigs. Graybill(3) and Riley(7) likewise report negative results with *Heterakis papillosa,* a nematode parasitic in the cæcum of chickens and other birds, whose development following ingestion of embryonated eggs took place in the normal habitat of this parasite. I have repeatedly fed the eggs of *Ascaridia perspicillum,* a nematode parasitic in the intestines of chickens, to guinea pigs and chicks and I have been unable to demonstrate migrations of the larvæ despite careful and tedious examinations of the liver, lungs, and other organs. On the contrary, I found that the larvæ develop in the lower portion of the small intestine of guinea pigs and chicks where they increase considerably in size. Ransom,(6)

on the other hand, found larvæ in the lungs of a guinea pig that had been fed infective larvæ of the stomach worm of sheep and cattle, *Haemonchus contortus*.

Füllerborn,(2) who carried out some preliminary experiments with the pinworm of man, *Enterobius* (*Oxyuris*) *vermicularis*, expresses the view that a migration of the larvæ of this parasite to the liver and lungs appears improbable, in view of the phylogenetic position of the Oxyuridæ.

The failure to find larval migrations in the Heterakidæ (*Heterakis* and *Ascaridia*), a group that is zoölogically more closely related to the Ascaridæ than are the Oxyuridæ, does not warrant the expectation, from the phylogenetic viewpoint, that the larvæ of oxyurids undergo migrations comparable to those of ascarids.

DEVELOPMENT OF OXYURIS EQUI IN THE HORSE

Railliet and Henry(5) described larval forms of *Oxyuris equi* from the horse measuring from 5 to 10.5 millimeters, in which the anus was situated relatively far from the posterior extremity; they also described larvæ of less-common occurrence, from 5 to 6 millimeters in length, in which the distance of the anus from the posterior extremity was shorter than in the former types. Railliet and Henry expressed the opinion that these forms represented males and females, respectively, and they predicted that following one more molt (the final larval molt), sex differentiation would become apparent. Recently Ihle and Van Oordt(4) found larvæ of *Oxyuris equi* in a similar stage of development, the smallest form measuring a little less than 3 millimeters. These writers also found molting forms and their observations on these larvæ established the correctness of the opinions expressed by Railliet and Henry regarding sexual differentiation of the larvæ subsequent to the final larval molt.

SUMMARY AND CONCLUSIONS

The data presented in the foregoing pages can be briefly summarized as follows:

1. Long-tailed horse oxyurids (*mastigoides* type) commonly oviposit in vitro, the eggs being segmented when they are discharged from the uterus. Uterine eggs that are liberated by cutting up female worms are nonsegmented and do not develop in vitro. Short-tailed oxyurids (*curvula* type) rarely oviposit in vitro. Eggs that are normally discharged from these forms develop normally in vitro.

2. Oviposition is preceded by marked peristaltic movements of the uterus, and following the expulsion of the eggs the females become quiescent and exhibit no further signs of vitality.

3. The eggs of *Oxyuris equi* develop rapidly and are embryonated in about four days.

4. Exposure of eggs to air appears to be requisite to development. The moisture content of the eggs is protected by a gluey water-insoluble substance, which accounts for the readiness with which the parasites develop in a dry place.

5. Continued exposure of embryonated eggs to environmental conditions (dry and moist) results in a gradual lowering of their vitality, and after a few weeks of such exposure they lose their vitality entirely.

6. Embryonated eggs of *Oxyuris equi* hatch in vitro, but the larvæ die in water as a result of plasmoptysis. The larvæ retain their vitality for a short time in physiological salt solution, and although they show sluggish movements they do not molt in vitro.

7. In guinea pigs hatching larvæ were not observed in the stomach. Emergence of larvæ from the eggshell through the birth pore in the shell that is guarded by the operculum occurred in the small intestine.

8. *Oxyuris equi* larvæ were rapidly eliminated from the digestive tract of guinea pigs, and no evidence of an invasion of the liver, lungs, and other organs could be found in these animals.

9. The life history of *Oxyuris equi* appears to be simple and direct. Following oral infection, the larvæ hatch in the intestine, settle down in the cæcum and colon, and by successive molts attain sexual differentiation.

10. On the basis of the foregoing observations it can be safely concluded that the eggs of *Oxyuris equi* must be eliminated from the host before development can take place, and that horses become infected as a result of swallowing water or food that has become contaminated with the eggs.

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ILLUSTRATIONS

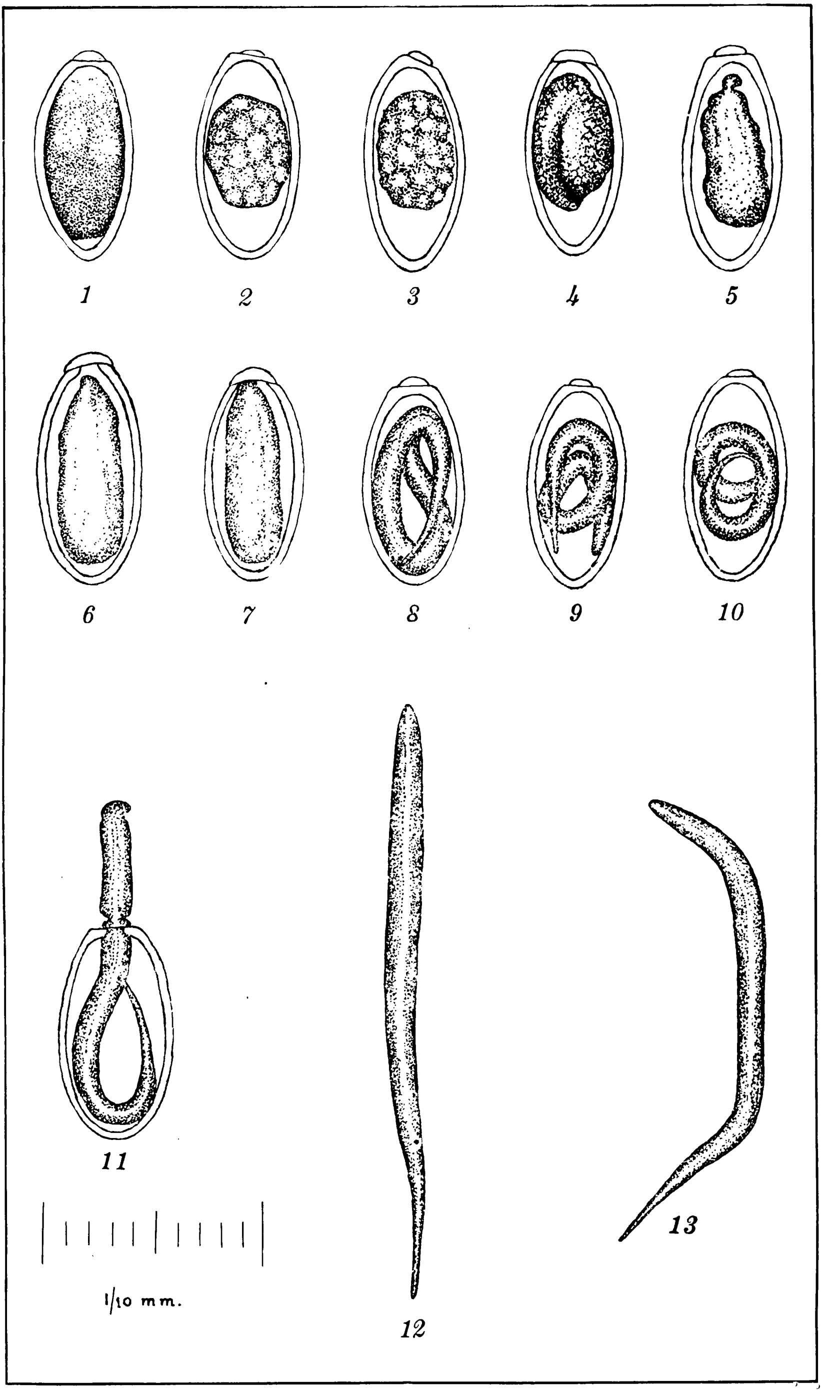

PLATE 1. EGGS AND LARVÆ OF OXYURIS EQUI.

METABOLISM EXPERIMENTS WITH FILIPINO STUDENTS IN THE UNITED STATES [1]

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Published studies on the nutrition of the Filipinos are very few. Aron and Hocson's work (3) is the only metabolic balance experiment on Filipinos reported in the literature. The need for further investigation along this line is therefore evident. The present paper is intended as a forerunner of other work of a similar nature which is being undertaken by the biological chemistry section of the College of Agriculture, University of the Philippines.

REVIEW OF THE LITERATURE

The following review of the literature shows that very little study has been done on the nutrition of Filipinos.

A food, to be adequate, must furnish the body not only with the necessary calories in the form of proteins, fats, and carbohydrates, but also with enough of the inorganic elements of which the body is composed. In addition to these, the so-called vitamines are indispensable.

In general it can be said that, given a free choice, the Filipinos, just as any other people, will take adequate diet. Instinct plays an important rôle in this. Unfortunately, one cannot always get the food he wants, and is thus forced to take whatever is available. Poverty and lack of supply are what generally limit the food choice of an individual.

Carbohydrates.—Rice is very rich in carbohydrates and, since it is the principal food of Filipinos, it is very easy to see that they are surely getting enough of this foodstuff for the needs of the body. Aron (1) found that the Filipino prisoners in Manila were getting an average of 510 grams of carbohydrates daily, and that a Filipino workman consumed 525 grams. Roxas and

[1] The data in the present paper are taken from the dissertation presented by me for the degree of Doctor of Philosophy, Yale University, 1922.

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Collado(17) calculated that the average intake of each student who ate in the college mess at the College of Agriculture, Los Baños, was 506 grams of carbohydrates daily. Collado (unpublished) has found that the carbohydrate intake of each student in that college who prepared his meals himself was 521 grams, while that of the barrio (rural) people was 444 grams. When we consider the small stature of Filipinos, we can see that they are getting a much greater quantity of carbohydrates than is demanded by the Voit standard.

Fats.—Osborne and Mendel(15) have shown that it is possible for animals to live without eating more than traces of true fat. According to Aron(1) Filipino prisoners got 27 grams of fat per man daily. Roxas and Collado found that at the students' mess mentioned the fat intake was 38 grams per person. Collado found that students who cooked their food themselves consumed 20 grams each daily, and the barrio people, 14 grams. It will be observed that the intake of fat was proportional to the pecuniary ability of the people. The students who ate at the mess were generally better off financially than those who cooked their food themselves, and the barrio families investigated were poorer than the students.

Inorganic salts.—From what foods do the Filipinos get their necessary quota of inorganic salts? Analysis of most of their food materials for inorganic constituents is lacking, so that an answer to this important question cannot even be attempted. Aron and Hocson found that a diet consisting principally of rice and vegetable foods did not cover the demand of the body for phosphorus. Polished rice is low in ash, and especially in phosphorus, and a diet of rice, plus bread, bacon, fish, and other foods poor in this element was not enough to produce a positive phosphorus balance. The balance became positive when unpolished rice, rice bran, or phytin was added to the ration. The studies of the diet of the people in Los Baños by Roxas and Collado indicate that the Filipino dietary may be deficient in calcium.

In connection with this problem, two habits of some of the people, which may possibly indicate that their common food is poor in inorganic salts are worth mentioning: (*a*) The bones of the fish are usually eaten as well as the meat. It has been stated already that rice is low in ash. Dry fish is a very common food. (*b*) While as a rule the unmarried Filipino women do not chew buyo and betel leaves and smoke neither cigars nor cigarettes, when they get married and become pregnant or when nursing, many of them, especially the poor ones, get the "buyo-chewing"

habit[3] and eat cigar or cigarette ash. It is not uncommon to find pregnant women who dislike the smell of tobacco, but who nevertheless eat the ash.

Proteins.—Is the protein requirement of Filipinos the same as that of other people? Careful consideration of all the literature up to date shows that this question cannot be answered at present. It is my intention to study this phase in the near future. Aron and Hocson found that it was not possible to establish nitrogen equilibrium with the simple Filipino diet of rice, bread, fish, sugar, bacon, and coffee, even in cases where the nitrogen intake was comparatively high (8.5 to 9.95 grams per day) if the total caloric intake was less than 1,800 calories per 50 kilograms of body weight. They state further: (3)

> * * * On the other hand, if the number 1,800 was equalled or exceeded, then 9 grams of nitrogen per 50 kilograms of body weight were sufficient. If a less quantity of nitrogen than the above figure was taken with the food, then the loss of nitrogen exceeded the amount taken, even if the number of calories reached 2,200. However, with an intake of 5 to 6 grams of nitrogen, the deficit amounted to less than 2 grams * * *.

From this they deduced that in some instances 8 grams of nitrogen per 50 kilograms of body weight, or 0.16 gram per kilogram of body weight, would be sufficient. Their value was higher than the lowest limit found by other authors who have succeeded in establishing nitrogen equilibrium on 0.1 gram per kilogram of body weight.

Collado found that the average intake of each member of two poor families in Los Baños was 9.4 grams nitrogen with a total of 2,090 calories. The prisoners in Manila were found by Concepcion (9) to have an average daily intake of 8.5 grams of nitrogen with a total of 1,799 calories. Although the latter author was of the opinion that the amounts found by Collado and by himself were sufficient to keep the body in nitrogen equilibrium, Aron and Hocson's finding that at least 1,800 calories per 50 kilograms of body weight are needed to preserve nitrogen equilibrium led him to conclude that the requirement of calories estimated by Collado and by himself was not adequate for the body. The reason for this conclusion is not obvious. According to Aron and Hocson's results at least 36 calories per kilogram of body weight are needed to keep the body in nitrogen balance. Collado's data show that his subject had an intake of 40 calories

[3] Thick paste of calcium hydroxide is spread on fresh betel leaves. This together with the buyo is a favorite chew of many women.

per kilogram of body weight (2,090 per 52 kilograms of body weight). Concepcion's data show an intake of 35 calories per kilogram of body weight (1,799 per 52 kilograms of body weight). Aron and Hocson concluded that when the caloric requirement of 1,800 per 50 kilograms of body weight was satisfied, 0.16 gram nitrogen per kilogram of body weight was sufficient to establish nitrogen balance. The nitrogen intake of Collado's subjects was 0.18 gram per kilogram of body weight, and that of Concepcion's 0.15 gram. Hence, it is reasonable to assume that the subjects of these two investigators were getting enough nitrogen to prevent loss of this element from the body.

EXPERIMENTAL

The following nitrogen-metabolism experiments were conducted to find out whether it is possible for Filipinos, who have resided one year or more in the United States and have become accustomed to American diet, to remain in nitrogen equilibrium when given a Filipino food of rice, fish, meat, and vegetables. The subjects, all males and healthy, were four Philippine Government students taking post-graduate courses at Yale.

To simplify the analyses and the preparation of the foods, salmon and ham were used as the fish and meat foods, respectively, while lettuce, sweet potato, and banana formed the vegetables. The nitrogen was determined in the food as prepared for eating, and control determinations were made now and then to guarantee that the nitrogen content of each particular food did not vary too widely.

Except for the coffee and the little powdered milk and sugar which go with it for the sake of savor, no restriction was made as to the amount of food each subject should take. All were allowed to eat as much as they wanted. To lessen the monotony of the ration, meat and fish were given on alternate days, as was also done with potatoes and lettuce.

The period at which the actual analyses were made was preceded by a preliminary period of at least three days, during which the actual experimental diet was ingested. Charcoal in gelatin capsules was used for marking the fæces; the latter was mixed with a little alcohol and hydrochloric acid before drying on the water bath. Thymol was used as a preservative for the urine. The food was purchased and cooked by me.

Methods used.—The acidity was determined by titration with 0.1 *N* sodium hydroxide, according to Folin's method; total nitrogen, by Kjeldahl's; creatinine, by Folin's colorimetric; uric

acid, by Folin-Shaffer's; sodium chloride according to Volhard-Arnold; and calcium oxide, by McCrudden's method. All of these procedures are described in the excellent manual of Underhill.(18) The caloric value of the different foods was estimated from Atwater's(4) tables for American food materials. The surface area was calculated by the use of Meeh's formula, and the Du Bois value of 39.7 calories(13) per square meter of body surface was taken as the standard in calculating the basal metabolism.

DISCUSSION OF RESULTS

As will be seen in Tables 1 to 8, a positive nitrogen balance was obtained in all of the series. In no case was the caloric intake of each person less than 14 per cent above the basal requirement, a value calculated by Lusk as the excess, above the starvation minimum, needed for maintenance. Little change in weight was observed in any of the subjects.

Table 9 shows the average daily nitrogen and the caloric intake of the four Filipinos concerned.

Table 10 shows that the students consumed more calories per kilogram of body weight than either the people of Los Baños or the prisoners in Manila; more than is required by the Voit, the Rubner, or the Chittenden(6, 7) standard; but less than the recorded intake of Japanese students (Oshima, 16) or the intake required by Atwater's standard (Lusk, 13).

A study of the nitrogen intake (Table 10) shows that my subjects ingested more nitrogen than the reported intake of Filipinos living in the Philippines; more than the intake of Japanese students; and almost as much, per kilogram of body weight, as required by the accepted American and European standards. Almost one-half of the nitrogen intake of the students investigated by Collado, and more than two-thirds of the intake of Aron and Hocson's subjects, came from the rice eaten. Less than one-third of the nitrogen intake of my subjects came from rice. The reasons for the comparatively high intakes of meat (nitrogenous food) are obvious. Animal foods are usually more expensive than either the vegetable or the cereal foods. Collado's subjects paid for the food they ate. Aron and Hocson intentionally made rice the basis of their diet, from which it can be deduced that they did not amply provide meat for their men. Aron(2) also found that the people of Taytay obtained more than half of their nitrogen need from rice. They, likewise, paid for their food. Besides, it is the habit of the majority of the people

in the Philippines to eat as much rice and as little meat as possible. Some take meat only to improve the taste of the rice. Mothers often say to the children, "Be sparing with your meat, but always eat much rice."

As mentioned above, my subjects had been in America for more than one year and were therefore accustomed to American diet. Naturally they longed for Filipino food. During the experiments the food was given to them gratis. Since there was no restriction as to the amount they should eat, it was no wonder that they ate to their hearts' content, and consumed much more meat than do their countrymen at home. That they enjoyed the rations was shown in their desire that the experiments be continued longer.

Observations made among some of the Filipino students in New York City who cooked their food themselves showed that, when they had plenty of money, they ate more meat and less rice than when in pecuniary difficulty.

Incidentally it will be noted that F.O.S. (Tables 1, 2, and 3) had a higher nitrogen intake in the second period than in the first and third. In the first period he was eating alone; in the second also he was alone, but took 5 grams of brewers' yeast daily; and in the third, he had a companion at the table. Did yeast serve as an appetite improver here? (Cowgill, 10; Karr, 12.)

The nitrogen and the caloric intakes of my subjects were all higher than Aron and Hocson found necessary for establishing nitrogen equilibrium; herein lies the reason for their giving positive nitrogen balance in all cases.

URINE ANALYSES

The analyses of the urine (Table 11), compared with those of other urines as given in Table 12, show nothing of particular interest.

The average specific gravity is lower and the average daily volume larger than those of the urine of Filipinos living in the Philippines, but not than those of white men living in either the Temperate or the Tropic Zones. The difference in both the volumes and the specific gravities may be partly explained by the difference in temperature; my experiments were made in late fall while those in the Philippines, it should be borne in mind, were performed at tropical temperature.

The urinary nitrogen figures are also higher than those for other tropical people observed in their own localities (see Table

12). This is due to the greater comparative nitrogen intake of the subjects investigated, in conformity with the well-known fact that, within certain limits, the nitrogen metabolism can be maintained at different levels.

The acidity is lower than that of the average urines of Europeans or Americans, but higher than that of the urines of the people of Singapore (Campbell, 5).

Table 13 shows the day and night variations in some of the constituents of the urine of F.O.S.

SUMMARY

Filipinos who had become accustomed to American food showed positive nitrogen balances when given their native diet, and this diet as selected furnished enough calories for the nutritive equilibrium.

The results obtained were compared with previous work done in the Philippines.

Analyses of urines for some of the constituents are recorded.

ACKNOWLEDGMENT

I desire to express my hearty thanks to Prof. Lafayette B. Mendel for suggesting this subject and for his advice during the progress of the work.

TABLE 1.—*Food intake of F.O.S., October 26 to 29, 1920.*

Food.	October 26.	October 27.	October 28.	October 29.	Total food.	Nitrogen.	
	g.	*g.*	*g.*	*g.*	*g.*	*P. ct.*	*g.*
Rice	673	615	793	693	2,774	0.42	11.65
Salmon	159		163		322	4.15	13.36
Ham		120		97	217	4.69	10.17
Lettuce	59		68		127	0.21	0.26
Sweet potato		176		216	392	0.15	0.59
Banana	130	123	65	107	425	0.22	0.94
Milk	1	1	1	1	4	4.12	0.16
Coffee	1	1	1	1	4	3.73	0.15
Sugar	25	25	25	25	100	0.00	0.00
Two gelatin capsules							0.04

Nitrogen balance.

	Grams.
Total intake in food	37.32
Output in urine	30.57
Output in fæces	5.02
Total output in excreta	35.59
Balance, four-day period (plus)	1.73
Balance, average per day (plus)	0.43

Caloric intake.

	Cals.
Total estimated caloric intake	6,270
Average estimated daily intake	1,570
Estimated basal metabolism	1,370

Caloric intake, 15 per cent above basal metabolism.

Body weight, without clothing.

	Kilograms.
October 26	40.1
October 30	39.4

TABLE 2.—*Food intake of F.O.S., November 8 to 11, 1920.*

Food.	November 8.	November 9.	November 10.	November 11.	Total food.	Nitrogen.	
	g.	*g.*	*g.*	*g.*	*g.*	*P. ct.*	*g.*
Rice	831	761	956	849	3,397	0.42	14.27
Salmon	--------	121	--------	148	269	4.15	11.16
Ham	160	--------	148	--------	308	4.69	14.44
Lettuce	59	--------	69	--------	128	0.21	0.26
Sweet potato	--------	217	--------	258	475	0.15	0.71
Banana	72	101	118	100	391	0.22	0.86
Milk	1	1	1	1	4	4.12	0.16
Coffee	1	1	1	1	4	3.73	0.15
Sugar	25	25	25	25	100	0.00	0.00
Yeast	5	5	5	5	20	7.58	1.51
Two gelatin capsules	--------	--------	--------	--------	--------	--------	0.04

Nitrogen balance.

	Grams.
Total intake in food	43.56
Output in urine	33.52
Output in fæces	6.83
Total output in excreta	40.35
Balance, four-day period (plus)	3.21
Balance, average per day (plus)	0.80

Caloric intake.

	Cals.
Total estimated caloric intake	7,180
Average estimated daily intake	1,790
Estimated basal metabolism	1,370

Caloric intake, 31 per cent above basal metabolism.

Body weight, without clothing.

	Kilograms.
November 8	40.0
November 12	39.4

TABLE 3.—*Food intake of F.O.S., November 27 to 30, 1920.*

Food.	November 27.	November 28.	November 29.	November 30.	Total food.	Nitrogen.	
	g.	*g.*	*g.*	*g.*	*g.*	*P. ct.*	*g.*
Rice	734	763	814	866	3,177	0.42	13.34
Salmon		135		156	291	4.15	12.07
Ham	102		178		280	4.69	13.13
Lettuce	46		48		94	0.21	0.19
Sweet potato		235		222	457	0.15	0.68
Banana	148	102	166	90	506	0.22	1.11
Milk	1	1	1	1	4	4.12	0.16
Coffee	1	1	1	1	4	3.73	0.15
Sugar	25	25	25	25	100	0.00	0.00
Two gelatin capsules							0.04

Nitrogen balance.

	Grams.
Total intake in food	40.87
Output in urine	32.40
Output in fæces	6.98
Total output in excreta	39.38
Balance, four-day period (plus)	1.49
Balance, average per day (plus)	0.37

Caloric intake.

	Cals.
Total estimated caloric intake	7,100
Average estimated daily intake	1,770
Estimated basal metabolism	1,370

Caloric intake, 29 per cent above basal metabolism.

Body weight, without clothing.

	Kilograms.
November 27	40.0
December 1	39.2

TABLE 4.—*Food intake of J.L.C., November 27 to 30, 1920.*

Food.	November 27.	November 28.	November 29.	November 30.	Total food.	Nitrogen.	
	g.	*g.*	*g.*	*g.*	*g.*	*P. ct.*	*g.*
Rice	930	832	899	1,034	3,695	0.42	15.51
Salmon		208		131	339	4.15	14.06
Ham	149		130		279	4.69	13.08
Lettuce	30		49		79	0.21	0.16
Sweet potato		219		162	381	0.15	0.57
Banana	257	181	289	171	898	0.22	1.97
Milk	1	1	1	1	4	4.12	0.16
Coffee	1	1	1	1	4	3.73	0.15
Sugar	25	25	25	25	100	0.00	0.00
Two gelatine capsules							0.04

Nitrogen balance.

	Grams.
Total intake in food	45.70
Output in urine	34.93
Output in fæces	8.64
Total output in excreta	43.57
Balance, four-day period (plus)	2.13
Balance, average per day (plus)	0.53

Caloric intake.

	Cals.
Total estimated caloric intake	8,030
Average estimated daily intake	2,000
Estimated basal metabolism	1,430

Caloric intake, 40 per cent above basal metabolism.

Body weight, without clothing.

	Kilograms.
November 27	43.1
December 1	43.2

TABLE 5.—*Food intake of J.L.C., December 4 to 7, 1920.*

Food.	December 4.	December 5.	December 6.	December 7.	Total food.	Nitrogen.	
	g.	*g.*	*g.*	*g.*	*g.*	*P. ct.*	*g.*
Rice	1,106	821	1,096	1,201	4,224	0.42	17.74
Salmon		151		233	384	4.15	15.93
Ham	133		222		355	4.69	16.64
Lettuce	76		35		111	0.21	0.23
Sweet potato		198		106	304	0.15	0.45
Banana	227	154	249	290	920	0.22	2.02
Milk	1	1	1	1	4	4.12	0.16
Coffee	1	1	1	1	4	3.73	0.15
Sugar	25	25	25	25	100	0.00	0.00
Two gelatine capsules							0.04

Nitrogen balance.

	Grams.
Total intake in food	53.36
Output in urine	37.78
Output in fæces	8.27
Total output in excreta	46.05
Balance, four-day period (plus)	7.31
Balance, average per day (plus)	1.82

Caloric intake.

	Cals.
Total estimated caloric intake	8,900
Average estimated daily intake	2,220
Estimated basal metabolism	1,430

Caloric intake, 55 per cent above basal metabolism.

Body weight, without clothing.

	Kilograms.
December 4	43.0
December 8	43.6

TABLE 6.—*Food intake of E.G.A., December 4 to 7, 1920.*

Food.	December 4.	December 5.	December 6.	December 7.	Total food.	Nitrogen.	
	g.	g.	g.	g.	g.	P. ct.	g.
Rice	1,021	1,008	1,010	895	3,934	0.42	16.52
Salmon		152		186	338	4.15	14.02
Ham	217		149		366	4.69	17.16
Lettuce	43		31		74	0.21	0.15
Sweet potato		134		141	275	0.15	0.41
Banana	238	247	242	293	1,020	0.22	2.24
Milk	1	1	1	1	4	4.12	0.16
Coffee	1	1	1	1	4	3.73	0.15
Sugar	25	25	25	25	100	0.00	0.00
Two gelatine capsules							0.04

Nitrogen balance.

	Grams.
Total intake in food	50.85
Output in urine	43.56
Output in fæces	6.01
Total output in excreta	49.57
Balance, four-day period (plus)	1.28
Balance, average per day (plus)	0.32

Caloric intake.

	Cals.
Total estimated caloric intake	8,590
Average estimated daily intake	2,140
Estimated basal metabolism	1,690

Caloric intake, 26 per cent above basal metabolism.

Body weight, without clothing.

	Kilograms.
December 4	55.2
December 8	55.7

TABLE 7.—*Food intake of E.G.A., December 11 to 14, 1920.*

Food.	December 11.	December 12.	December 13.	December 14.	Total food.	Nitrogen.	
	g.	g.	g.	g.	g.	P. ct.	g.
Rice	805	1,062	889	925	3,681	0.42	15.46
Salmon		220		267	487	4.15	20.21
Ham	199		191		390	4.69	18.29
Lettuce	66		72		138	0.21	0.29
Sweet potato		149		100	249	0.15	0.37
Banana	200	136	235	260	831	0.22	1.82
Milk	1	1	1	1	4	4.12	0.16
Coffee	1	1	1	1	4	3.73	0.15
Sugar	25	25	25	25	100	0.00	0.00
Two gelatine capsules							0.04

Nitrogen balance.

	Grams.
Total intake in food	56.79
Output in urine	45.50
Output in fæces	10.10
Total output in excreta	55.60
Balance, four-day period (plus)	1.19
Balance, average per day (plus)	0.30

Caloric intake.

	Cals.
Total estimated caloric intake	8,480
Average estimated daily intake	2,120
Estimated basal metabolism	1,690

Caloric intake, 25 per cent above basal metabolism.

Body weight, without clothing.

	Kilograms.
December 11	55.0
December 15	55.3

TABLE 8.—*Food intake of J.M.E., December 11 to 14, 1920.*

Food.	December 11.	December 12.	December 13.	December 14.	Total food.	Nitrogen.	
	g.	*g.*	*g.*	*g.*	*g.*	*P. ct.*	*g.*
Rice	1,159	994	1,180	1,009	4,342	0.42	18.23
Salmon		209		222	431	4.15	17.88
Ham	180		156		336	4.69	15.75
Lettuce	46		60		106	0.21	0.22
Sweet potato		256		374	630	0.15	0.94
Banana	206	150	224	242	822	0,22	1.80
Milk	1	1	1	1	4	4.12	0.16
Coffee	1	1	1	1	4	3.73	0.15
Sugar	25	25	25	25	100	0.00	0.00
Two gelatine capsules							0.04

Nitrogen balance.

	Grams.
Total intake in food	55.17
Output in urine	44.08
Output in fæces	6.81
Total output in excreta	50.89
Balance, four-day period (plus)	4.28
Balance, average per day (plus)	1.07

Caloric intake.

	Cals.
Total estimated caloric intake	9,650
Average estimated daily intake	2,410
Estimated basal metabolism	1,540

Caloric intake, 56 per cent above basal metabolism.

Body weight, without clothing.

	Kilograms.
December 11	48.0
December 15	48.3

TABLE 9.—*Average daily nitrogen and caloric intake of the Filipinos investigated.*

Name.	Body weight.	Total nitrogen.	Nitrogen per kilogram of body weight.	Total calories.	Calories per kilogram of body weight.
	Kilos.	*g.*	*g.*		
F.O.S	40	10.16	0.25	1,710	42
J.L.C	43	12.38	0.28	2,110	49
E.G.A	55	13.46	0.24	2,130	39
J.M.E	48	13.79	0.29	2,410	50
Average	47	12.45	0.26	2,090	45

TABLE 10.—*Nitrogen and caloric intake of Filipinos as compared with well-known dietary standards.*

	Body weight.	Total nitrogen.	Nitrogen per kilogram of body weight.	Total calories.	Calories per kilogram of body weight.
	Kilos.	*g.*	*g.*		
Rubner standard	70	20.3	0.29	2,860	41
Voit standard	70	18.8	0.27	3,050	43
Atwater standard	70	20.0	0.28	3,400	49
Chittenden standard	70	9.4	0.13	2,600	37
Japanese students	44	8.6	0.20	2,260	51
People in Los Baños	52	9.4	0.18	2,090	40
Prisoners in Manila (Concepcion)	52	8.5	0.16	1,799	35
Filipinos (Aron and Hocson)	50	8.0	0.16	1,800	36
Filipino students at Yale	47	12.4	0.26	2,090	45

TABLE 11.—*Analyses of urines of Filipino students at Yale University (1920).*

Subject.	Date.	Specific gravity 1.0.	Volume.	Acidity 0.1 *N* sodium hydroxide.	Total nitrogen.	Creatinine.	Uric acid.	Sodium chloride.	Calcium oxide.
	1920		*cc.*	*cc.*	*g.*	*g.*	*g.*	*g.*	*g.*
F.O.S	October 26	0.013	1,180	269	7.48	1.26	0.28	8.9	0.37
Do	October 27	0.012	980	235	7.31	1.11	0.43	4.8	0.19
Do	October 28	0.012	1,120	230	7.64	1.22	0.39	5.3	0.22
Do	October 29	0.012	1,240	203	8.14	1.03	0.29	6.0	0.27
Do	November 8	0.014	960	221	8.62	1.11	0.38	4.6	0.19
Do	November 9	0.012	1,100	238	7.74	1.24	0.39	5.4	0.22
Do	November 10	0.017	895	233	8.46	1.05	0.48	6.0	0.21
Do	November 11	0.014	1,115	313	8.70	1.29	0.39	5.7	0.23
J.L.C	November 27	0.016	985	204	8.04	1.12	0.48	6.9	0.23
Do	November 28	0.017	850	207	8.24	1.30	0.49	6.0	0.22
Do	November 29	0.025	690	132	8.60	1.26	0.60	7.0	0.18
Do	November 30	0.017	1,120	282	10.05	1.44	0.58	9.3	0.23
E.G.A	December 4	0.025	760	168	10.53	1.57	0.53	7.8	0.14
Do	December 5	0.017	1,180	300	11.65	1.68	0.70	7.2	0.13
Do	December 6	0.016	1,600	154	11.63	1.64	0.74	7.3	0.19
Do	December 7	0.014	1,250	266	9.75	1.52	0.51	7.7	0.15
J.M.E	December 11	0.023	910	234	11.01	1.47	0.56	9.0	0.22
Do	December 12	0.030	665	288	11.21	1.63	0.64	7.6	0.25
Do	December 13	0.016	1,400	243	10.29	1.41	0.55	10.9	0.22
Do	December 14	0.017	1,285	300	11.57	1.45	0.76	8.1	0.27
Average		0.016	1,064	236	9.33	1.34	0.51	7.1	0.22

TABLE 12.—*Comparison of the analyses of the urines of the Filipino students at Yale with other normal urines.*

	Body weight.	Specific gravity 1.0.	Volume.	Acidity 0.1 *N* sodium hydroxide.	Total nitrogen.	Nitrogen per kilogram of body weight.	Creatinine.	Uric acid.	Sodium chloride.	Calcium oxide.
	Kilos.		*cc.*	*cc.*	*g.*	*g.*	*g.*	*g.*	*g.*	*g.*
Europeans (McCay, 1908)	70.0	0.020	1,440	----------	18.00	0.26	1.55	0.75	15.0	----------
Americans (Folin, 1905)	63.0	0.022	1,430	617	16.00	0.25	1.55	0.37	10.1	----------
Bengalis (McCay, 1908)	52.0	0.013	1,200	----------	6.00	0.11	----------	0.45	10.0	----------
Races in Singapore (Campbell, 1919)	52.0	0.016	1,046	281	8.39	0.16	1.10	0.33	6.0	----------
Europeans in the Tropics (Young, 1915)	60.0	0.021	1,070	----------	11.49	0.19	----------	----------	----------	----------
Filipinos in the Philippines (Concepcion, 1918)	51.0	0.019	936	----------	7.01	0.14	1.48	0.37	5.8	----------
Medical students in the Philippines (Concepcion, 1918)	51.0	0.021	924	----------	7.75	0.15	1.69	0.44	5.7	----------
Filipino students at Yale	47.0	0.016	1,064	236	9.33	0.20	1.34	0.51	7.1	0.22

TABLE 13.—*Day and night variations in the urine of F.O.S.*

Date.	Specific gravity 1.0.		Volume.		Acidity 0.1 *N* sodium hydroxide.		Total nitrogen.		Creatinine.	
	Day.	Night.	Day.	Night.	Day.	Night.	Day.	Night.	Day.	Night.
1920			*cc.*	*cc.*	*cc.*	*cc.*	*g.*	*g.*	*g.*	*g.*
October 26	0.013	0.014	740	440	126	143	3.93	3.55	----------	----------
October 27	0.010	0.014	510	470	87	148	3.15	4.16	----------	----------
October 28	0.010	0.015	680	440	102	128	3.68	3.96	----------	----------
October 29	0.014	0.010	575	665	95	108	4.52	3.62	----------	----------
November 8	0.010	0.018	540	420	84	137	4.05	4.57	0.56	0.55
November 9	0.011	0.013	560	540	95	143	3.58	4.16	0.63	0.61
November 10	0.017	0.017	415	480	100	133	3.56	4.90	0.52	0.53
November 11	0.012	0.016	635	480	117	196	3.93	4.77	0.62	0.67

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NOTES ON PHILIPPINE SHARKS, I

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ONE PLATE

Throughout the ages sharks have been of well-nigh universal interest. Without the gorgeous colors or flowerlike brilliancy of some fishes or the superb symmetry and grace of others, they yet irresistibly attract attention. Though as a rule of a dull uniform gray or bluish cast and without beauty of form, by their size, speed, greediness, and ferocity they have aroused curiosity from earliest times. Though a few sharks are notable for singularity of shape, it is their more degenerate and less-active kindred, the skates and rays, that have developed the strangest forms and the most uncanny powers.

Although some sharks attain a length of only a few inches, even when fully matured, as a whole they are of large size, and certain sharks and rays are the largest of all fishes. Many species of sharks are very ferocious when hungry and do not hesitate to attack any other animal in the water, regardless of its size. Sharks are no worse in this regard than many other fishes, as any very large carnivorous fish may be dangerous to man. Barracuda and the giant sea basses of the East Indies and Polynesia are more dreaded in some localities than are sharks. No shark is more ferocious or dangerous to man than are the small and apparently insignificant caribe fish of the South American rainy tropics.

The sharks and their allies represent an entirely distinct and divergent line from that of the bony fishes. They have no air bladder, no true scales, and no membrane bones, the operculum being always absent in the living species, while the skeleton not only presents a number of peculiarities but also is much less specialized both in form and in material, always remaining more or less cartilaginous. The shoulder girdle is not fastened to the skull but to one of the vertebræ some distance behind it, so that there is a neck similar to that in higher animals. The males of all living species have attached to the ventral fins a pair of claspers or copulatory organs. These serve as a penis

by whose agency the semen is transmitted into the oviducts, impregnation being therefore internal in all sharks except those of the genus *Somniosus*, which includes two species of arctic and subarctic seas.

The eggs are few and large and may be developed externally when, with the exception of those of *Somniosus*, they are covered with a thick leathery or horny skin, or case, or they may be developed within the body of the mother. The cases of some shark eggs are spirally twisted, others are quadrangular with each of the four corners produced into a long filament. The egg cases of rays are wheelbarrow-shaped, with four "handles." These handles and stringy filaments serve to attach the eggs to fixed objects. In some species of rays the egg cases contain several eggs, each of which may develop.

In many sharks, and in some rays, a part of the oviduct becomes enlarged into a uterus, and in some of the sharks a placenta is formed similar in appearance to that of mammals but different in development.

The skin of sharks and rays may be naked, or it may be provided with bony or horny plates, but usually it is covered with placoid scales. These scales are minute, closely set spines situated on a broader base, each spine consisting of dentine covered with enamel; the base is composed of bone and the whole scale therefore has the same essential structure as a tooth. Placoid scales are usually so firmly attached to the skin that it is very difficult to remove them, while they are so hard they will take a stonelike polish. Formerly large quantities of shark skins were used for polishing wood and ivory; their fineness, hardness, and durability made them far superior to any other abrasive available for work of the highest quality. Even in spite of the great improvements in making emery and sand paper, cabinet makers still use some shagreen.

The principal use made of shark skins for many years has been in the manufacture of sword grips and sheaths, card cases, jewel boxes, and other small articles. Within the past five years improved methods of removing the scales and of tanning shark skins have been perfected and a rapidly increasing shark leather business is being developed. Shark skins are nonporous and therefore make a leather practically water and air proof. The last-named quality is a serious defect in the manufacture of shoes, but does not impair the value of the leather for many other purposes.

Sharks and skates are of world-wide distribution and occur from the upper Silurian deposits onward. Although most species are more or less solitary in habit, a few sometimes occur in vast schools and are distinctly gregarious at all times.

Though sharks and skates are but little eaten by Europeans and their descendants, practically all are edible and a few species are really very good food, ignorance and prejudice alone preventing them from being extensively used as food. To an extent little realized they are being increasingly utilized in the United States. Many of those caught in traps along the Atlantic coast are cut up so as to be unrecognizable and are marketed under the name of "deep water swordfish." Certain sharks make an acceptable canned product, though owing to the prejudice against shark meat they have been marketed under another name.

In the Philippines several species of sharks and rays are commonly seen in the markets and are esteemed as food. In some parts of the Islands, especially in the Sulu Archipelago, large numbers of sharks are caught for the fins alone, little use being made of the rest of the fish. The dried fins are exported to China, where they are in great demand as the basis for a delicious soup. The liver of sharks and rays is very rich in oil and in some parts of the world fisheries have been maintained for generations for the purpose of obtaining the oil, the rest of the animal being thrown away. Most of the oil is used in soap making, tanning, and other industries, but the best grade is refined and used as "cod-liver oil."

No systematic shark fisheries are conducted in the Philippines, but in the Sulu Archipelago many sharks are caught with hook and line or speared. Many others are captured in the fish traps which line the coasts, though their presence there or their capture in nets is more or less accidental.

In the modern method of developing shark fisheries the sharks are caught in specially designed gill nets, as ordinary nets are ruined by them. The hides are made into leather, the fins are prepared for the Chinese trade, and the oil is extracted from the livers; the meat and bones are cooked and ground into stock food and fertilizer. There are many localities in the Philippines where a large and profitable business in sharks could be developed. The preparation and export of shark fins is a business capable of great expansion. The choicest varieties fetch a very high price but Filipino fishermen make no systematic effort to get the better kinds, while the Chinese merchants who dry and

salt fish have such slipshod methods that their product is often inferior.

Most kinds of sharks are harmless to man, and they are not a serious menace to bathers in the Philippines; nevertheless, they are a factor to be considered in many places. Occasionally some one is either killed outright by a shark, so badly bitten as to die shortly afterward, or is seriously wounded. Bathing beaches having a reef or bar in front of them are usually safe, but bathers should never venture alone into deep water in the Philippines.

There are no authentic records of rays attacking man, though the gigantic rays known as mantas or "sea devils" are greatly feared by pearl divers. The sting rays, which have one or more large barbed spines on the long and flexible tail, inflict dangerous wounds when stepped upon. The jagged spine causes frightful injury and, due to the slime and dirt forced into the wound, infection usually follows.

Sawfish never attack man intentionally, but due to their size, strength, and terrific weapon they are greatly and justly dreaded when entangled in nets or caught in traps.

The sharks and rays of the Philippines are very imperfectly known, not more than half of the species being listed or represented in existing collections. Although they form a group of considerable economic importance in the Philippines this lack of knowledge is not surprising, since it is very difficult to collect and preserve the large adult forms.

In the present paper is described a new species, the type of a new genus, obtained at Dumaguete, Oriental Negros, in March, 1922. With it were also caught two other sharks, small dogfish, reported only once before from the Philippines. These three sharks were captured in a fish corral a few meters off shore, in water not over 6 meters deep.

Genus **HEMITRIAKIS** novum

This genus is distinguished from *Triakis*, to which it is most closely related, by the differences in the teeth, in the shape of the snout, in the lobe of the nasal valve, in the shape of the body, and in the subcaudal lobe.

Head much depressed anteriorly, flattened beneath except beneath the moderately long and pointed snout, where it is slightly convex; eyes with prominent nictitating membrane over lower portion; spiracles very small, behind eyes; nostrils very

far apart, without nasoral groove; mouth arched, with prominent labial folds; teeth of medium size, two transverse rows functioning in upper jaw and three in lower; in upper jaw are a few (two or three rows) very small erect median teeth with a central sharp-pointed cusp and usually two smaller ones at each side of its base; the remaining teeth are much larger, strongly oblique, with a longer sharp-pointed cusp directed outward toward the angle of the mouth, and with two or three much smaller denticles on the outer side; in lower jaw the teeth of the six median rows are larger than the upper median teeth, are erect or nearly so, and have a central cusp with from no denticles to three small ones on each side of base; the remaining rows are of teeth smaller than the opposing upper teeth, strongly oblique, with a larger cusp directed toward angle of mouth and one to four minute cusps or denticles on outer side; the fifth pair of gill slits is the smallest and is over the pectoral; the first dorsal is over the space between pectorals and ventrals, but much nearer the former; origin of second dorsal in advance of anal; caudal rather short, without a pit at its base, with a notch in the subcaudal lobe, and a moderately developed anterior lobe.

Body not compressed; lateral line noticeable, rather high up, beginning on head.

Hemitriakis leucoperiptera[1] sp. nov. Plate 1.

Head 4.775 in length, its greatest breadth a trifle more than half (50.4 per cent) of its own length; snout 3$\frac{1}{13}$ in head; eyes 6$\frac{1}{4}$ in head and a trifle less than twice in interorbital space; spiracles 5$\frac{1}{3}$ in eyes; depth 7.95 in total length and 6.31 in length without caudal fin.

Head long, its profile descending very sharply from predorsal region, its anterior portion very low and depressed, with flattened crown and interorbital space; eyes large, much elongated, with a broad shagreen-covered nictitating fold; the small, slit-like spiracles just behind eyes; snout rather long and pointed, with a slightly rounded tip; nostrils as far apart as possible and nearer mouth than tip of snout; each anterior valve has an outer triangular pointed flap near inner angle of nostril and under and at right angles to it a smaller dividing fold or flap; each posterior valve has a slight fold, or ridge, near inner angle; mouth crescentic, its transverse length equal to interorbital space, with well-developed labial folds, the outer parallel with contour of head

[1] *Leucoperiptera* from λευκος, white; πεπι, around; and πτεπόυ, wing, or fin, in allusion to the white margin of the fins.

and half again as long as inner which parallels lower lip; teeth in $\frac{18}{34}$ rows, their description given under that of the genus.

Third gill slit largest and contained 8 in length of head; fifth smallest, being approximately three-fourths as large as third; in the type specimen margin of second gill slit on right side is curiously modified, running above and beyond third gill slit, as shown in the figure; this is evidently a congenital malformation.

Inner margin of pectorals four-fifths as long as outer margin, which is 0.8 the length of head; origin of first dorsal above posterior margin of pectorals; rear margin of both dorsals and anal crescentic, inner angle of each produced in a long pointed tip; origin of anal opposite middle of second dorsal; caudal rather short, a trifle less than the length of head; subcaudal narrow with a pointed and moderately long lobe near its origin and a notch near its extremity, the lobe 2.44 in length of caudal, with a deeply concave posterior margin; supracaudal rather thick, low, very little elevated.

Body very deep just before first dorsal, with a low dermal ridge between the dorsals and on the long caudal peduncle; trunk and tail rounded, not at all compressed; tail longer than head and trunk together, or 52.3 per cent of the entire length; scales small, very rough except on head where they are smooth, those on caudal smaller, five keeled, the central one terminating in a strong sharp point; numerous conspicuous mucus pores on top of snout and extending back as far as crown.

Color nearly uniform dark gray above lateral line, darkest on crown and snout and in front of first dorsal; paler below, becoming whitish or with a yellowish cast beneath; all the fins have a narrow white posterior margin.

Here described from the type specimen, a pregnant female, 955 millimeters long over all, obtained by me at Dumaguete in March, 1922, and containing twelve young nearly ready for delivery.

There are six females, varying in length from 202 to 218 millimeters, and six males, five ranging from 200 to 208 millimeters and one 220 millimeters long. All vary in certain particulars from the mother. The head is contained from 4.3 to 5 times in the total length; the extreme elevation of the predorsal region is wanting, the depth being contained from 9.3 to 10 times in the total length; the crown and interorbital region are also slightly convex. There is a black blotch on both dorsals and on the tip of the supracaudal, and two black blotches on the caudal peduncle

behind the second dorsal. As in all young the eyes are larger than in the adult, being contained 4 times or less in the head, while the spiracles are more open and about 4 in the eye. The subcaudal lobe is very slightly developed, its elongation evidently being a post-embryonic development.

Squalus fernandinus Molina. DOG FISH.

Squalus fernandinus MOLINA, Saggio sulla storia nat. Chili (1782); GARMAN, The Plagiostomia, Mem. Mus. Comp. Zool. Harvard College **36** (1913) 195.

Squalus philippinus SMITH and RADCLIFFE, Proc. U. S. Nat. Mus. **41** (1912) 677, pl. 51, fig. 1.

The genus *Squalus* is typically one of cool, temperate waters and is primarily distinguished by the conspicuous stout sharp spine in front of both the first and the second dorsal fins, and by the teeth which are alike in both jaws, with obique cusps and cutting edges nearly parallel with the edge of the jaw.

Smith and Radcliffe described a small male *Squalus*, 325 millimeters long, from the west coast of Luzon, under the name of *Squalus philippinus*. It was dredged off Sombrero Island, at a depth of 236 fathoms.

It is therefore a matter of considerable interest to find two more specimens, this time in shallow water, the species being apparently not considered rare by the Dumaguete fishermen.

My specimens are both females; they measure, respectively, 645 and 655 millimeters long over all. I follow Garman in placing *philippinus* under the synonymy of *S. fernandinus*.

Measurements.

	mm.	mm.
Length without caudal	515	530
Length over all	645	655
Head	140	153
Width of head	84	85
Snout from mouth	61	61
Snout from eye	47	47
Eye	30	31
Interorbital space	52	54
Mouth	45	45
Snout to origin of first dorsal	197	185
Origin of first dorsal to origin of second dorsal	210	235
Base of first dorsal	45	55
Base of second dorsal	30	45
Second dorsal to origin of caudal	70	70
Widest gill opening	15	15

ILLUSTRATION

[Drawings by M. Ligaya.]

PLATE 1. HEMITRIAKIS LEUCOPERIPTERA G. ET SP. NOV.

FIG. 1. Adult female, one-third natural size.
2. Gill slits on right side, showing congenital malformation.
3. Underside of snout.
4. A young male, taken from the female shown in fig. 1.

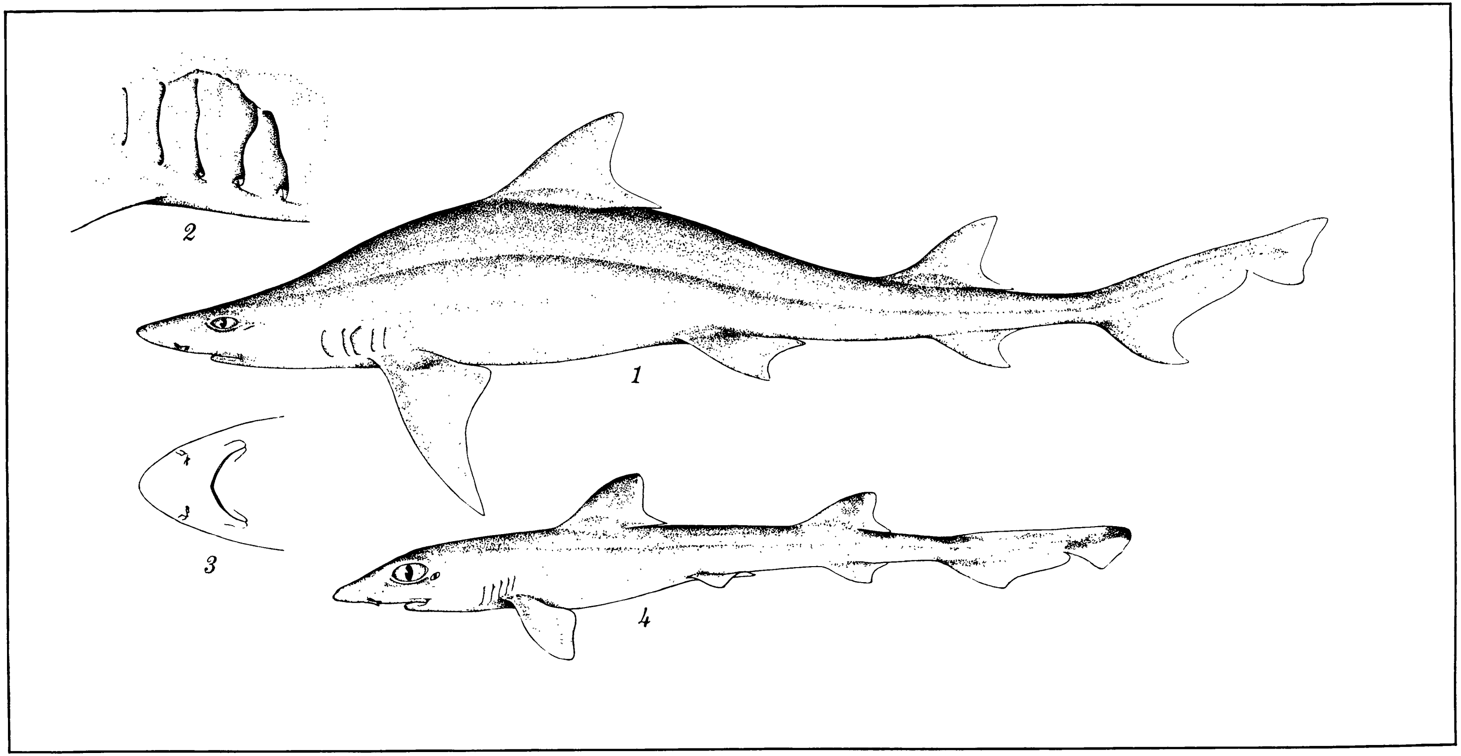

PLATE 1. HEMITRIAKIS LEUCOPERIPTERA G. ET SP. NOV.

A NEW PHILIPPINE PAUSSID, SYNONIMICAL NOTES ON PACHYRRHYNCHUS, AND A NEW SPECIES OF THE LATTER

By W. SCHULTZE

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ONE TEXT FIGURE

Cerapterus herrei sp. nov.[1] Text fig. 1.

Related to *C. latipes* Swederus. Head, antennæ, pronotum, and legs black. Elytra shining black, broader than pronotum, at apical third with an irregular, dentate, yellowish, rufescent patch. This marking is larger and of different shape than that in *C. latipes*. Head, front smooth toward vertex, irregularly rather densely asperate or rugose and finely setose. Antennæ, first joint with rather coarse and irregularly scattered asperities and also more strongly setigerous. Second to ninth joints finely setose, particularly at outer margins. Pronotum strongly asperate at anterior margin, otherwise smooth, with a feebly pronounced, elongate depression at middle, the margins with a setose fringe. Legs scatteringly punctate and finely setose.

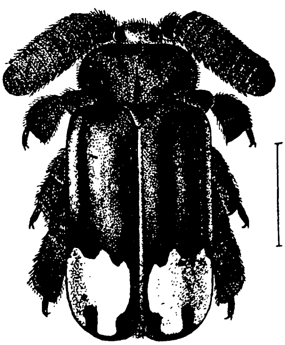

FIG. 1. *Cerapterus herrei* sp. nov.

Length, 13.8 millimeters.

MINDANAO, Lanao Province, Sacred Mountain, near Camp Keithley (*A. W. Herre*). Type in the collection of the Bureau of Science, Manila.

I name this interesting species in honor of its collector, who found it under some loose bark. From the same tree Doctor Herre collected a species of ant, *Polyrhachis bihamata* Drury, but whether the paussid has any relation to this formicid or not I am unable to say.

[1] Still another paussid (*Paussus catocanthus*) was lately described by Gestro, Boll. della Soc. Ent. Ital. 55 (1923) 5.

NOTES ON PACHYRRHYNCHUS

During January, 1923, I received upon request, through the kindness of Mr. G. J. Arrow, certain species of *Pachyrrhynchus* which have been compared with the types in the British Museum, together with several undetermined *Metapocyrtus* species.

The *Pachyrrhynchus* species are the following:

Pachyrrhynchus venustus Waterhouse.
Pachyrrhynchus rufopunctatus Waterhouse.
Pachyrrhynchus latifasciatus Waterhouse.
Pachyrrhynchus schoenherri Waterhouse.
Pachyrrhynchus inclytus Pascoe.

Unfortunately, none of the specimens bears any locality except "Philippines." A careful examination of the above specimens gave the following results:

Pachyrrhynchus schoenherri Waterhouse is, in general form, related to *P. erichsoni* Waterhouse, but is easily distinguished from the latter by the different general color and the location of the spots on the elytra, particularly a bifid sutural spot behind the middle and another bifid sutural spot near the apex.

Pachyrrhynchus inclytus Pascoe has been recognized by me in an earlier paper [2] as being identical with *P. modestior* Behrens. Professor Heller in 1912 also suspected this to be the case, but it was not until now that I could convince myself conclusively of this fact. The typical specimen of *P. inclytus* Pascoe from the British Museum differs slightly from the commoner forms of *P. inclytus* Pascoe; it has, in the middle of the elytra near the suture, as well as between the first and second longitudinal stripes, some spots which appear as a rudimentary crossband. In the usual form, which may be designated *P. inclytus* var. *modestior* Behrens, the spots are wanting. Behrens also mentioned the typical form of *P. inclytus,* calling it *P. modestior* var. γ. Heller [3] in 1921 described still another variation, *P. modestior* var. *transversatus.* This variation as described merely represents a combination of the characters of *modestior* var. β and var. γ Behrens.

Pachyrrhynchus latifasciatus Waterhouse is an isolated species and very distinct from the other members of the genus.

Under the name *Pachyrrhynchus venustus* Waterhouse not less than three distinct species have been confounded, probably

[2] Philip. Journ. Sci. 21 (1922) 577. [3] Philip. Journ. Sci. 19 (1921) 544.

due to lack of sufficient properly preserved material and the great similarity in the general appearance of the species involved. The typical specimen of *P. venustus* from the British Museum before me agrees perfectly with the original description of Waterhouse and, furthermore, is identical with my Mindanao species *P. virgatus* Schultze,[4] of which I have numerous perfect examples. *Pachyrrhynchus venustus* and *P. rufopunctatus* Waterhouse are not identical; Waterhouse was certainly correct in considering them as nearly related but distinct species. The typical specimen of *P. rufopunctatus* Waterhouse before me also agrees very well with the original description. I received several specimens of these species from Polillo. The confusion concerning *P. venustus* was started by Behrens[5] in 1887. This author identified *P. rufopunctatus* and another species (which was then and is still undescribed) as *P. venustus*, but he evidently did not have the latter at all. The following extract from his description clears up this point:

In der Sammlung des Ersten findet sich ein einzelnes Stück mit flacherer Rüsselgrube, länglicheren, hinten weniger verschmälerten Flügeldecken, auf denen zarte Punktstreifen angedeutet sind und 22 lilafarbige Schuppenflecken stehen (ein weiterer zwischen den beiden Basalflecken). Dieses Stück dürfte wahrscheinlich nur eine Varietät des *P. venustus* sein. Nach Waterhouse variirt die Fleckenzahl auf den Flügeldecken zwischen 16 und 22, vielleicht haben die ♂ weniger Flecken als die ♀. Die Art *P. rufopunctatus* Waterh., die *P. venustus* sehr nahe stehen soll, und deren Diagnose bei Waterhouse * mit der von *P. venustus* gleichlautet, wird wohl nur eine leichte Varietät dieser Art darstellen.

* *P. venustus.* Niger, laevis; capite macula una inter oculos; thorace maculis duabus supra, maculaque una ad utrumque marginem, elytris viginti-duabus ovatis ornatis; his e squamis auratis, vel aureo-cupreis, effectis.

P. rufopunctatus. Niger, laevis; capite maculis tribus; thorace maculis duabus supra, maculaque una ad utrumque marginem, elytris viginti-duabus ornatis, his maculis e squamis rufis effectis.

It is clear from a comparison of the above descriptions by Waterhouse which Behrens quotes, that the two diagnoses are not identical, contrary to Behrens's assumption and interpretation. *Pachyrrhynchus venustus,* which he characterizes as having "22 lilafarbige Schuppenflecken," is a new species, which I shall describe below as *P. confusus* sp. nov.

In 1911 Professor Heller identified specimens from our collection, the species with the "lilafarbige" spots, as *P. venustus*

[4] Philip. Journ. Sci. **15** (1919) 549, pl. 1, fig. 1.
[5] Stett. Ent. Zeitg. **48** (1887) 251–253.
* Waterhouse, Trans. Ent. Soc. III, p. 310, 311.

Waterhouse, and in his determination table for the *Pachyrrhynchus* species describes it as follows:[6]

> Flügeldecken schwarz mit rötlichen, blass lilafarbigen, oder weisslichen Makeln.. P. venustus Waterh.

From this it is clear that he also was mistaken with respect to this species. In 1918, on the strength of the determination of Professor Heller, I published some biological notes on the false *Pachyrrhynchus venustus*,[7] and in 1922 I figured the penis structure,[8] also under the wrong name. The following remarks will serve to clear up matters concerning the above species of *Pachyrrhynchus:*

Pachyrrhynchus venustus Waterhouse.

Pachyrrhynchus venustus WATERHOUSE, Proc. Ent. Soc. London (1841) 18; Trans. Ent. Soc. London I 3 (1843) 310; Ann. Mag. Nat. Hist. I 8 (1842) 218; BOHEM., Schönh. Gen. Curc. VIII 2 (1844) 381.
Pachyrrhynchus virgatus SCHULTZE, Philip. Journ. Sci. 15 (1919) 549, pl. 1, fig. 1, ♀; ibid. 21 (1922) 593, pl. 3, fig. 7.

This species is shiny black and the elytra are impunctate. The scale spots are reddish or coppery golden metallic, and in fresh specimens are strongly opalescent. The spots laterad on the prothorax are roundish, not oblong-oval. The number of spots on the elytra is variable, as in the other related species.

MINDANAO, Surigao Province. DINAGAT.

Pachyrrhynchus venustus subsp. **insulanus** Schultze.

Pachyrrhynchus virgatus subsp. *insulanus* SCHULTZE, Philip. Journ. Sci. 15 (1919) 550.

This subspecies is uniform black and is known only from Siargao and Bucas Grande Islands.

Pachyrrhynchus rufopunctatus Waterhouse.

Pachyrrhynchus rufopunctatus WATERHOUSE, Proc. Ent. Soc. London I 4 (1842) 45; Trans. Ent. Soc. London I 3 (1843) 311.
Pachyrrhynchus venustus BEHRENS, Stett. Ent. Zeitg. 48 (1887) 251; HELLER, Philip. Journ. Sci. § D 7 (1912) 307.

Black, moderately shiny, the elytra impunctate and very finely rugose. The scale spots are reddish. The spots on the prothorax are oblong-oval.

POLILLO (*W. Schultze*).

[6] Philip. Journ. Sci. § D 7 (1912) 307.
[7] Philip. Journ. Sci. § D 13 (1918) 276, pl. 1, figs. 10 and 11.
[8] Ibid. 21 (1922) 593, pl. 3, fig. 2.

Pachyrrhynchus confusus sp. nov.

Pachyrrhynchus venustus BEHRENS, Stett. Ent. Zeitg. **48** (1887) 251; HELLER, Philip. Journ. Sci. § D 7 (1912) 307; SCHULTZE, Philip. Journ. Sci. § D **13** (1918) 276, pl. 1, figs. 10 and 11; ibid. **21** (1922) 593, pl. 3, fig. 2.

Black, shiny, the elytra very finely rugose, with indistinct interrupted longitudinal rows of punctures. The scale spots very pale lilac, in old specimens sometimes whitish. Rostrum evenly but scatteredly punctate, basal half with an oblong depression and a longitudinal medial groove. Front with a squarish scale spot, and another smaller one, below the eyes. Prothorax as long as broad, the greatest width at the middle, finely and scatteredly punctate. Laterally, in the middle between the anterior and posterior margin, an oblong-oval spot. At each lateral margin, another, larger scale spot. Each elytron with two large oblong-oval basal spots, one discally, the other laterally; sometimes a small roundish spot is located between the two. Three other spots before the middle, of which the one located at the lateral margin is very oblong reaching backward beyond the middle. On the apical third another cross row of two or three spots and a triangular spot at the apex. Aside from the aforementioned spots each elytron bears a sutural spot at the middle and another on the apical fourth. Apical sutural termination of the elytra obtusely pointed in the female.

Male, length, 16 millimeters; width, 6.5. Female, length, 17.3 millimeters; width, 7.5.

LUZON, Laguna Province, Los Baños (*W. Schultze*). In a swamp, feeding on the fern *Acrostichum aureum* Linn.

193326——6

ILLUSTRATION

Text fig. 1. *Cerapterus herrei* sp. nov.

NIGHT AND DAY RATES OF ELONGATION OF BANANA LEAVES [1]

By Sam F. Trelease

Of the Johns Hopkins University, Baltimore, Maryland

It is well known that the aërial parts of plants usually enlarge faster at night than in the daytime, if the temperature remains about the same. Growing plant organs may even shrink during the day instead of elongating. An example of this may be taken from the results of a study of growth in *Cestrum nocturnum,* made by Brown and Trelease. [2] It was found that the young shoots wilted and actually shortened during periods of exposure to direct sunlight on dry days, but that they elongated rapidly at night; they showed no elongation in the daytime excepting in the late afternoon, after they had returned to their early morning length. Measurable enlargement depends principally upon an increase in the water content of enlarging cells. The fact that the growth rate is usually higher for the night than for the day is apparently related to a higher water content of the plant as a whole in the night; [3] it is at least safe to suppose that it depends upon a higher night water content of the enlarging cells.

The present paper aims to illustrate, by means of a series of measurements, the relative elongation rates of leaves of a banana [*Musa sapientum* Linn. var. *cinerea* (Blanco) Teod.], locally known as *latundan,* by day and by night, and to present some observations on variations in leaf position that appear to be related to corresponding variations in foliar water content.

[1] Botanical contribution of the Johns Hopkins University, No. 73.

[2] Brown, W. H., and Trelease, S. F., Alternate shrinkage and elongation of growing stems of Cestrum nocturnum, Philip. Journ. Sci. § C **13** (1918) 353–360.

[3] Livingston, B. E., and Brown, W. H., Relation of the daily march of transpiration to variations in the water content of foliage leaves, Bot. Gaz. **53** (1912) 309–330; Lloyd, F. E., Leaf water and stomatal movement in Gossypium and a method of direct visual observation of stomata in situ, Bull. Torrey Bot. Club **40** (1913) 1–26; Shreve, Edith B., The daily march of transpiration in a desert perennial, Carnegie Inst. Washington Pub. **194** (1914).

The study was made in 1919, during the latter part of the dry season (May), at the College of Agriculture, Los Baños, Laguna, Philippine Islands. It is a pleasure to acknowledge indebtedness to Prof. B. E. Livingston for suggestions in the preparation of this paper, and to Mr. Felix Maceda for assistance in securing the measurements.

LEAF ELONGATION

The leaf elongation of ten selected plants was measured at 6 a. m. and at 6 p. m., for five days. The method used was based on that described by Copeland[4] for measuring leaf enlargement of the youngest visible leaf of the coconut. A transverse line was drawn with ink across the bases of the youngest leaf (leaf 1) and the next to the youngest leaf (leaf 2) where the latter overlapped the former, about half of the line being on each leaf. Since the two adjacent leaves do not elongate at the same rate, the two parts of this line are soon shifted with reference to each other, one leaf sliding upon the other as growth proceeds. At the end of the twelve-hour period the vertical distance between the two parts of this line showed the difference in elongation between the two leaves. A similar line drawn across the bases of leaf 2 and the next older leaf (leaf 3) was used to measure the difference in elongation between these two leaves. Older leaves were marked and observed similarly, it being assured that the oldest leaf considered had already ceased to elongate at the time of marking. The sum of all the differences thus shown was taken as a measure of the elongation of the youngest leaf, for the period.

It is evident that if a represents the distance between the two line parts for leaves 1 and 2, b the corresponding distance for leaves 2 and 3, c the distance for leaves 3 and 4, d the distance for leaves 4 and 5, etc., then the entire elongation of leaf 1 is measured by the sum $a + b + c + d + \ldots\ldots + l$, in which l represents the measured distance for the oldest pair of leaves showing any measurable shifting of the line parts. Similarly, the growth of leaf 2 is given by $b + c + d + \ldots\ldots + l$; of leaf 3, by $c + d + \ldots\ldots + l$; of leaf 4, by $d + \ldots\ldots + l$; and, finally, of leaf n, by l, there being n elongating leaves. The elongation of all visible leaves taken together is represented by the sum of the series $a + 2b + 3c + 4d + \ldots\ldots + nl$. Although the enlargement of the youngest visible leaf repre-

[4] Copeland, E. B., The Coco-nut. London, Macmillan and Co. (1914) 212.

sented such a large proportion of the total leaf elongation that it alone might have been used as a close approximation of that total, nevertheless it was considered advisable in the present tests to employ the total elongation of all visible leaves.

It must be mentioned here that the method just described fails to take into account the growth of the young leaves before they make their appearance above the false trunk, composed of overlapping leaf bases. This method is, however, the one which may be most satisfactorily applied to the growth of banana and abacá plants.

The results of these measurements are given in Table 1, which shows the day and following night increments of total leaf elongation of the ten banana plants, for the five consecutive days, May 14 to May 18, inclusive. The table also shows the total twenty-four-hour increment, and the ratio obtained by dividing the night increment by the preceding day increment.

In spite of the great variability of the different plants during the same day and of the same plant during the different days, the data shown in Table 1 illustrate the outstanding fact that, as is true of most plant organs which have been studied in this respect, these banana leaves usually elongated much more during the night than during the day, this fact being brought out by the records of individual plants as well as by the averages for each day. As shown in Table 1, the average ratios of night elongation to preceding day elongation for these five days were 1.7, 5.5, 1.5, 2.5, and 3.3. The highest ratio value for the whole series was 32.0, for plant 4 on May 15 to 16 (the ratio for plant 3 on May 18 to 19 has no meaning, since there was no measurable elongation during the day), and the lowest ratio value was 0.2. For the first day, eight of the ten plants showed greater elongation during the night than during the day, one showed less, and one the same as during the day. For the second day, nine plants showed greater elongation during the night, and one showed less. For the third day, however, only six plants showed greater elongation at night, and four showed less than during the day. For the fourth day, eight plants showed greater elongation during the night and two showed less than during the day. For the fifth day, seven plants showed greater elongation during the night, two showed less, and one the same as during the day.

Turning to the day and night rates themselves and to the total twenty-four-hour rates, attention should be called to plant

TABLE 1.—*Day and following night increments of total leaf elongation of ten banana plants, in the open and unshaded, for five consecutive days.*

Plant.	First day, May 14-15.				Second day, May 15-16.			
	Day period.	Night period.	Total.	Ratio night to day.	Day period.	Night period.	Total.	Ratio night to day.
	cm.	*cm.*	*cm.*		*cm.*	*cm.*	*cm.*	
1	9.2	11.5	20.7	1.3	1.9	7.8	9.7	4.1
2	1.3	1.3	2.6	1.0	0.8	1.1	1.9	1.4
3	0.4	0.9	1.3	2.3	0.2	0.7	0.9	3.5
4	0.8	1.6	2.4	2.0	0.1	3.2	3.3	32.0
5	2.7	4.3	7.0	1.6	2.5	3.6	6.1	1.4
6	5.8	3.6	9.4	0.6	2.5	4.3	6.8	1.7
7	1.5	3.4	4.9	2.3	1.1	3.9	5.0	3.5
8	1.6	2.1	3.7	1.3	2.4	2.1	4.5	0.9
9	0.8	1.9	2.7	2.4	0.8	4.1	4.9	5.1
10	3.2	6.9	10.1	2.2	2.4	3.3	5.7	1.4
Average	2.7	3.8	6.5	1.7	1.5	3.4	4.9	5.5

Plant.	Third day, May 16-17.				Fourth day, May 17-18.			
	Day period.	Night period.	Total.	Ratio night to day.	Day period.	Night period.	Total.	Ratio night to day.
	cm.	*cm.*	*cm.*		*cm.*	*cm.*	*cm.*	
1	3.9	5.8	9.7	1.5	1.1	3.9	5.0	3.5
2	0.8	0.6	1.4	0.8	0.2	1.1	1.3	5.5
3	0.4	1.4	1.8	3.5	0.3	0.9	1.2	3.0
4	4.5	2.2	6.7	0.5	0.7	0.9	1.6	1.3
5	4.6	1.8	6.4	0.4	4.7	7.7	12.4	1.6
6	4.3	3.0	7.3	0.7	1.1	2.5	3.6	2.3
7	3.7	3.9	7.6	1.1	0.5	1.9	2.4	3.8
8	1.2	1.6	2.8	1.3	0.9	2.3	3.2	2.6
9	0.5	1.9	2.4	3.8	1.1	0.7	1.8	0.6
10	1.3	2.1	3.4	1.6	1.5	1.3	2.8	0.9
Average	2.5	2.4	5.0	1.5	1.2	2.3	3.5	2.5

Plant.	Fifth day, May 18-19.			
	Day period.	Night period.	Total.	Ratio night to day.
	cm.	*cm.*	*cm.*	
1	5.8	1.1	6.9	0.2
2	0.7	7.7	8.4	11.0
3	0.0	0.2	0.2	--------
4	2.1	13.4	15.5	6.4
5	36.0	49.3	85.3	1.4
6	5.7	14.4	20.1	2.5
7	0.3	1.3	1.6	4.3
8	0.3	1.5	1.8	5.0
9	3.3	2.2	5.5	0.7
10	2.9	2.9	5.8	1.0
Average	[a] 2.3	[a] 5.0	[a] 7.3	3.3

[a] Average derived from data for only nine plants, the value for plant 5 being disregarded.

5 for the fifth day, in which case the rates are clearly very exceptional. No special explanation for the exceedingly high rates of this plant for that day is suggested; and the day, night, and twenty-four-hour values for plant 5 have been disregarded in the computation of the average rates for the fifth day. In all other cases the daily averages given in Table 1 are derived regularly.

The mean increments in elongation for the five night periods were 3.8, 3.4, 2.4, 2.3, and 5.0 centimeters, respectively; for the preceding day periods they were 2.7, 1.5, 2.5, 1.2, and 2.3 centimeters, respectively; and for the twenty-four-hour periods they were 6.5, 4.9, 5.0, 3.5, and 7.3 centimeters, respectively. Aside from the exceptional case just mentioned, the greatest total leaf elongation for the twelve-hour nocturnal period was 14.4 centimeters (plant 6, fifth day), the greatest for the diurnal period was 9.2 centimeters (plant 1, first day), and the greatest for the twenty-four-hour period was 20.7 centimeters (plant 1, first day). The smallest elongations were 0.2 centimeter for the nocturnal, zero for the diurnal, and 0.2 centimeter for the twenty-four-hour period.

Although these rates of elongation may be considered as representative of what may be expected for banana leaves under environmental conditions similar to those here dealt with, the growth rate must in general be more or less markedly influenced by the climatic conditions (generally grouped as climate, season, and weather), as well as by the internal conditions of the plant (usually grouped as the variety of plant; its tone, or health condition; and its phase of development). The pronounced variation shown in the elongation rates given in Table 1 may possibly have been due to corresponding variations in the environmental conditions, or they may have been directly related to internal variability among the plants themselves. Both groups of conditions may of course have been influential together.

An attempt was made to find out whether the growth data contain any evidence of influential differences between the external conditions of the several days. The question is, do the five days group themselves as good, poor, etc., for leaf elongation as indicated by the whole group of plants taken together? One way to approach this question is simply to examine the averages. Table 2 presents the five daily averages for each of the four kinds of data, each series of averages arranged in the descending order of magnitude.

TABLE 2.—*Nocturnal, diurnal, and twenty-four-hour average rates of leaf elongation for each of the five days, arranged in the descending order of magnitude in each case.*

Nocturnal averages.		Diurnal averages.		Total averages.		Ratio, night to preceding day.	
	cm.		*cm.*		*cm.*		
Fifth day	5.0	First day	2.7	Fifth day	7.3	Second day	5.5
First day	3.8	Third day	2.5	First day	6.5	Fifth day	3.3
Second day	3.4	Fifth day	2.3	Third day	5.0	Fourth day	2.5
Third day	2.4	Second day	1.5	Second day	4.9	First day	1.7
Fourth day	2.3	Fourth day	1.2	Fourth day	3.5	Third day	1.5

It is seen from Table 2 that, judging by the three average rates, the first day appears to have been generally much better for leaf elongation than was the fourth. The fifth day was apparently about as good as the first. It seems unsafe to attempt any more-detailed suggestions from these averages.

Another way to approach the same question was also tried. Each of the three series of elongation increments (fifty in each series) was arranged in the descending order, each value being accompanied by the number of the day in which it was obtained. Then the distributional frequency of the several day numbers was studied for the upper and the lower portion of each series. In all three series, day 4 had high frequencies among the low rate values and very low frequencies among the high values. The frequencies of the five day numbers were otherwise without suggestion in this connection. There was no evidence that the first day had exceptionally high values.

From these results it appears that the evidence is fairly strong that the conditions of the fourth day were characterized as poor for leaf elongation, with the added suggestion that possibly those of the first day were peculiarly good.

TABLE 3.—*Climatic data for period of growth measurements.*

Date.	Rainfall.	Temperature.		
		Maximum.	Minimum.	Mean.
	mm.	°*C.*	°*C.*	°*C.*
May 14	7.7	33.5	23.1	28.3
May 15	0.9	33.0	23.6	28.3
May 16	0.0	34.0	24.1	29.0
May 17	3.6	33.2	23.6	28.4
May 18	1.5	33.0	23.6	28.3
May 19	5.0	34.5	24.1	29.3

Data of rainfall and temperature for the days during which measurements were made are given in Table 3; but these data are not sufficient to allow any close comparison between them and the growth data, no clear relations being apparent. These climatic values indicate that the five days considered were very much alike with respect to the two main weather conditions usually employed in climatology.

As far as the available information goes, it is necessary to say that some portion of the variation shown in Table 1 was probably related to differences in the environmental conditions of the several days, but it is impossible to suggest just what conditions were thus effective, or to what degree. Certainly a large part of the variation was due to internal differences among the plants, differences within the plant body and not related to simultaneous differences in the surroundings.

Individual variation among apparently similar plants constitutes one of the greatest difficulties in the interpretation of the results of physiological studies. This is perhaps the most important question in the whole of plant physiology to-day, and it will probably remain so until we are able to obtain a group of plants that will agree within a small range of variation. Since the rates of elongation of these banana plants form a good example of individual variation, it appears important to call attention to the degree of variability that they exhibited.

It is seen at once from the data of Table 1 that the ten plants, selected as apparently alike, differed very greatly among themselves with reference to the total increment of leaf elongation for the same twenty-four-hour period, with reference to their day and night increments for the same day and night periods, and also with reference to the ratio of night increment to preceding day increment for the same day. These data illustrate the very high degree of variation that may be expected in a group of such plants, even when they appear by visual observation to be alike, and when all seem to have the same exposure. Averages based upon variables having such wide deviation are plainly not reliable unless properly understood; and the conclusions drawn from these data must of course be based upon a consideration of the variability exhibited.

The data of Table 1, just discussed, illustrate the great variability among the different plants during the same periods—that is, during each of the five days when measurements were made. It seems important to determine, also, how the plant

variability differed from day to day. If, for example, on one day a certain plant shows a very great increment, as compared with the increments of the other plants, does it show high relative increments on the other days? An answer to this question is brought out in Table 4, which shows the increments of total leaf elongation for each plant for each twenty-four-hour period, each increment being expressed as a percentage of the average increment for all plants for that day.

TABLE 4.—*Increments (for each of the five days) in leaf elongation for the twenty-four-hour period, these increments being expressed as percentages of the average of the ten plants for the day.*

Day.	Plant 1.	Plant 2.	Plant 3.	Plant 4.	Plant 5.	Plant 6.	Plant 7.	Plant 8.	Plant 9.	Plant 10.
First	319	40	20	37	108	145	75	57	42	155
Second	198	39	18	67	125	139	102	92	100	116
Third	194	28	36	134	128	146	152	56	48	68
Fourth	143	37	34	46	354	103	69	91	51	80
Fifth	95	115	3	212	([a])	275	22	24	75	79
Minimum	95	28	3	37	108	103	22	24	42	68
Maximum	319	115	36	212	354	275	152	92	100	155

[a] Omitted; see Table 1.

Table 4 shows that from day to day there was great variation in the relative rates of elongation; a plant may on one day show leaf elongation much below the average for all plants on that day, while on another day it may show an elongation greatly above the average. Thus it would be impossible to standardize each of these plants on one day and to predict their relative increments on a succeeding day. It is true that plants 2 and 3 always gave a relatively small daily increment, and that plants 1, 5, and 6 gave relatively high increments on most days; but their relative increments were not at all constant, and other plants varied, during the five-day period, from very low to very high relative increments.

In order to bring out possible relationships among the four different kinds of plant data, the data of Table 1 were rearranged to form a new table, in which the first vertical column gave the growth increments in a descending series, beginning with the largest day increment and ending with the smallest day increment. The table was then completed by placing in the second, third, and fourth columns, respectively, the night increment, the twenty-four-hour increment, and the ratio of the night increment to the day increment, corresponding to each of the day increments in the first column. The values in each

column were then separated into five groups, of ten each, and the average for each group was calculated. The averages are presented in Table 5. Besides the actual averages of the five groups of values, the table also shows the relative values of these averages, each expressed in terms of the uppermost one considered as 100.

TABLE 5.—*Relationships among data representing diurnal increment, nocturnal increment, twenty-four-hour increment, and ratio of nocturnal increment to diurnal increment; actual averages are given for each kind of data, and also values relative to the first in each column.*

Group of values, by diurnal increments.	Diurnal increment.		Nocturnal increment.		Twenty-four-hour increment.		Ratio, nocturnal to diurnal.	
	Actual.	Relative.	Actual.	Relative.	Actual.	Relative.	Actual.	Relative.
	cm.		*cm.*		*cm.*			
Highest ten [a]	5.39	100	5.68	100	11.07	100	1.03	100
Second ten	2.77	51	4.69	83	7.46	67	1.84	179
Third ten	1.36	25	2.81	49	4.17	38	2.01	195
Fourth ten	0.79	15	2.46	43	3.25	29	3.27	318
Lowest ten [b]	0.30	6	1.43	25	1.73	16	6.99	679

[a] Really the highest 9; see Table 1. [b] Really the lowest 9; see Table 1.

From Table 5 it is at once seen that progressively lower values of the day increment correspond to correspondingly lower values of the night increment and also of the twenty-four-hour increment. On the other hand, progressively lower values of the day increment correspond to progressively higher values of the night-day ratio. The range is greater and the differences are greater for the day increment than for the night increment. In a general way, night increments and twenty-four-hour increments vary directly with day increments, while ratios vary inversely with day increments. An explanation of the inverse relationship between the ratio values and the values for each of the three increments lies in the fact that the change in day increments is much more pronounced than the change in night increments, which remain relatively constant. The same approximate relationships suggested by the arrangement of all the data in the series just described are brought out by an examination of the records of the individual plants, showing the fluctuations from period to period in the rates of elongation.

LEAF POSITION

The two halves, right and left wings, of the banana leaf lie in nearly the same plane at night, like the right and left halves

of an ordinary flat leaf; but some wilting generally occurs in the day, and the two wings swing downward, about the midrib as an axis, so that their lower faces approach each other as wilting begins and progresses. These changes in leaf position are principally due to alterations in the turgidity of the cells in a double "hinge," composed of two narrow, colorless strips of tissue visible on the lower surface of the leaf, one along each side of the midrib for its entire length. By the action of the hinge, the two wings assume various positions, swinging upward or downward as if hinged to the midrib. The magnitude of the angle between the two wings may be approximated by determining the distance between the two free edges of the leaf; this distance may be called the apparent leaf width.[5] The apparent leaf width would become zero if the leaf were completely closed, which does not occur, however, in the case of banana leaves. Fluctuations in the apparent leaf width are probably approximate indices of corresponding fluctuations in the turgidity of the hinge cells, and these changes are probably primarily determined by the water content of these cells. The leaf movements may therefore be considered as indices of changes in foliar water content.

A study was made of the angular changes in the leaf wings, using forty-six selected leaves exposed to full sunlight, the apparent width of each leaf being measured every two hours, from 8 a. m. to 6 p. m., May 17. An equal number of similar leaves that were partly shaded during the day were also measured in the same manner. The averages of the values secured are shown in Table 6. The actual averages are given and also the corresponding relative values, the latter being expressed, for each series, as percentages of the actual value for 8 a. m.

An examination of the data of Table 6 shows that in each set the apparent width of the leaves decreased from 8 a. m. until noon, and then increased until 6 p. m. This may be taken to mean that the turgidity, and presumably the water content, of the hinge cells decreased until about noon and then increased in the afternoon. The reversible movements of the wings of these leaves are apparently due to alterations in the moisture content of the thin-walled hinge cells that lie in a row at each

[5] The trigonometrical reasoning on which this statement is based has been presented in another paper. See Trelease, Sam F., Incipient drying and wilting as indicated by movements of coconut pinnae, Am. Journ. Bot. 9 (1922) 253–265.

TABLE 6.—*Diurnal fluctuations in apparent leaf width for banana plants, each value representing the average for forty-six leaves, on May 17, 1919.*

Time of observation.	Leaves in sun.		Leaves in partial shade.	
	Actual.	Relative.	Actual.	Relative.
	cm.		*cm.*	
8 a. m.	21.7	100	25.0	100
10 a. m.	16.7	77	23.7	95
12 noon	7.4	34	19.4	78
2 p. m.	17.3	80	23.1	92
4 p. m.	20.1	93	24.4	98
6 p. m.	22.2	102	25.1	100

side of the midrib, the hinge cells apparently changing readily in shape or size or both, with even slight changes in their water content. The hinge cells appear to be peculiarly sensitive to changes in the water content of the leaf or of the plant as a whole, resulting from alterations in the relation between the rate of transpiration and the rate of water absorption by the roots. A water deficit, or a state of incipient drying, in a part or in all of the plant tissue may be expected to follow periods during which the transpiration rates have exceeded the rates of absorption. While the hinge cells appear to be particularly sensitive to water deficit, the water content of the plant as a whole probably follows, in a general way at least, the changes in water content of these cells. The results presented in Table 6 thus indicate that the leaves were nearly completely saturated with water at 8 a. m., and that after that hour the water content decreased progressively, reaching a minimum value some time between 10 a. m. and 2 p. m. The time of minimum apparent leaf width occurs somewhere within a period somewhat less than two hours; it may have occurred, as far as these measurements show, at almost any time between 10 a. m. and 2 p. m., although the minimum average reading was obtained at noon. Whenever this minimum actually occurred in this particular case, other observations on banana plants have shown that its time of occurrence differs, even for the same plant, for different days. This has also been found to be true in the case of the coconut. It will be noted that, as would be expected, the set of leaves exposed to full sunlight showed a much greater change than did those that were partially shaded, thus indicating a less-pronounced water deficit in the shaded leaves. By 6 p. m.

the leaves had apparently recovered the degree of saturation which they had had at 8 a. m. Other observations of banana plants showed that, although maximum expansion of the leaf wings usually occurred shortly after sunset, the plant as a whole became more turgid later in the night, this being indicated by increasing rigidity and elevation of the leaf midribs, as well as by a slightly greater diameter of the false trunk composed of overlapping leaf bases. The maximum expansion of the leaf wings was maintained throughout the night, and the wings began to approach each other again soon after sunrise on the succeeding day.

It appears that the turgor movements of such leaves as those of the banana furnish an index of leaf turgidity, and hence of leaf water content. If this be true, then the apparent leaf width might be an index of the rate of leaf elongation; and it might be possible, by employing this index, to relate the difference between the nocturnal and diurnal elongation rates, discussed in the first part of this paper, to corresponding differences in turgor. As is well known, enlargement does not take place in plant cells that are not turgid; enlargement requires an excess in the rate of water intake, above that of water loss. It is suggested that the two groups of phenomena dealt with in this paper may be closely related through the same causal condition, turgidity. But the experimental observations for growth rates and for leaf movements were not made for the same periods, and hence no direct evidence is available in this respect.

POTASSIUM FERROCYANIDE AS A REAGENT IN THE MICROSCOPIC QUALITATIVE CHEMICAL ANALYSIS OF THE COMMON ALKALOIDS

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TWO PLATES

The division of organic chemistry of the Bureau of Science is often called upon to determine the presence or absence of habit-forming drugs in minute amounts of material, such as a drop of liquid clinging to a syringe or a grain or two of powder in an otherwise empty container. Obviously, color tests are not feasible in such cases and recourse is had to microchemical reactions by which many tests can be made upon an exceedingly small amount of sample.

Descriptions of these tests are scattered throughout the literature. Wormeley's [1] classic on the microchemistry of poisons contains many tests and beautiful etchings. The various types of crystals formed by the reaction of such standard reagents as platinum or gold chloride are well known, but not so much attention has been paid to some of the less-common reagents. Among these potassium ferrocyanide should hold a prominent place. Behrens,[2] Grutterink,[3] Stephenson,[4] and others mention the use of potassium ferrocyanide as a reagent, but none of them gives a complete list of the alkaloids yielding characteristic crystalline precipitates with this reagent. I have tested forty of the common alkaloids [5] with potassium ferrocyanide. By

[1] Wormeley, T. G., Micro-chemistry of Poisons ed. 2 (1885).

[2] Behrens, H., Anl. zur mikrochemishe Analyse 3 (1896).

[3] Grutterink, A., Zeitschr. Anal. Chem. 51 (1912) 175.

[4] Stephenson, C. H., Some Microchemical Tests for Alkaloids (1921).

[5] The alkaloids tested were: Aconitine, apomorphine, arecoline, atropine, berberine, β-eucaine, brucine, caffeine, cinchonidine, cinchonine, cocaine, codeine, coniine, curare, emetine, ergotinine, heroine, homatropine, hydrastine, hyoscyamine, morphine, narceine, narcotine, nicotine, novocaine, papaverine, physostigmine, pilocarpine, piperazine, piperidine, piperine, quinine, quinoline, scopalamine, sparteine, stovaine, strychnine, theobromine, theophylline, veratrine.

the methods mentioned below, thirteen of these (β-eucaine, brucine, cinchonidine, cinchonine, cocaine, coniine, heroine, hydrastine, quinoline, sparteine, strychnine, stovaine, and veratrine) give characteristic crystalline precipitates. Bolland [6] states that apoatropine and hydrocotarnine give crystalline plates with potassium ferrocyanide. Grutterink [7] includes tropococaine and cotarnine. Unfortunately these four alkaloids were unobtainable by me. The crystalline compounds obtained are of the addition type, and probably have the general formula [8] $B_2.H_4Fe(CN)_6.X\ H_2O$.

The sensitivity and the best method of applying the tests have also been determined.

TECHNIC

The alkaloid or alkaloidal salt to be tested is dissolved in distilled water acidified with dilute hydrochloric acid. A drop of this solution is placed upon a miscroscope slide. The drop should not be more than 2 to 3 millimeters in diameter. Close to this drop is placed a smaller drop of a 5 per cent aqueous solution of potassium ferrocyanide. By means of a platinum wire or drawn-out glass rod, a tiny channel is made to flow from the reagent into the test drop. Usually an amorphous precipitate results which gradually becomes crystalline. If no precipitate appears, or if the precipitate remains amorphous after a minute or two, the preparation is vigorously scratched with a platinum or glass rod. In fact, I have found that, generally speaking, much more characteristic and perfect crystals result upon scratching and upon the use of comparatively dilute alkaloidal solutions. The drop is examined under a low power. The color, shape, crystal angles, polarization, extinction angles, and habit aid in the identification of the crystals under examination.

The sensitivity was obtained by testing solutions of the alkaloid in decreasing concentration until one was reached that failed to give crystals with the reagent within five minutes. The most-dilute solution, one drop of which yields crystals within five minutes, gives the sensitivity. The dilution of the drop by the reagent solution must of course be taken into consideration.

[6] Bolland, A., Monatsh. 32 (1910) 120, 129.

[7] Grutterink, A., Zeitschr. Anal. Chem. 51 (1912) 175.

[8] Cuming, W. M., Journ. Chem. Soc. 121 (1922) 1287.

β-EUCAINE

Sensitivity, 1 : 200.

β-eucaine forms with potassium ferrocyanide in hydrochloric acid solution colorless, thin, elongated, hexagonal or rhombic plates. They tend to grow to a very large size but they remain very thin. Under crossed nicols they are weakly polarized, exhibiting parallel and symmetrical extinction. Scratching of the preparation to induce crystallization is necessary. Plate 1, fig. 1.

BRUCINE

Sensitivity, 1 : 2,500.

Brucine forms with potassium ferrocyanide in hydrochloric acid solution highly refractive, stocky prisms with chisel-shaped ends. Usually the prisms occur in rosettes. Under crossed nicols the crystals are strongly polarized, exhibiting parallel extinction. There is a tendency toward supersaturation, and scratching of the preparation is necessary. Plate 1, fig. 2.

CINCHONIDINE

Sensitivity, 1 : 300.

Cinchonidine in hydrochloric acid solution yields with potassium ferrocyanide rosettes of yellow, curving, hairlike needles (Plate 1, fig. 3) when the concentration of the alkaloid is over 0.5 per cent. At 1 : 300 long thin rectangular yellow plates, exhibiting parallel extinction under crossed nicols, form near the edge of the drop. Scratching or seeding aid in the crystal formation.

CINCHONINE

Sensitivity, 1 : 1,000.

Cinchonine forms with potassium ferrocyanide in hydrochloric acid solution yellow, irregular, trapesium-shaped crystals, often grouping in the form of rosettes. They polarize strongly. Cinchonine is readily distinguished from cinchonidine and quinine by this test. Quinine does not yield a crystalline precipitate, and cinchonidine yields either hairlike crystals or thin rectangular plates. Plate 1, fig. 4.

COCAINE

Sensitivity, 1 : 500.

Cocaine forms with potassium ferrocyanide in hydrochloric acid solution colorless, six-sided plates and prisms of irregular shape. They polarize strongly under crossed nicols. On edge

they exhibit parallel extinction. Scratching of the preparation is usually necessary to induce crystallization.

The crystals tend to grow much thicker, polarize more strongly, and are more irregular in shape than those from β-eucaine. They form much more readily than those from heroine and do not form the spheroidal type of crystal characteristic of the latter. Stovaine is also readily distinguished from cocaine by this test. Plate 1, fig. 5.

CONIINE

Sensitivity, 1 : 50.

Coniine yields with potassium ferrocyanide in hydrochloric acid solution rosettes of colorless needles and long, thin, square-ended prisms. Scratching aids in the formation of the crystals. Under crossed nicols the crystals polarize weakly, exhibiting oblique extinction. The extinction angle is rather large, about 30°. Plate 1, fig. 6.

HEROINE

Sensitivity, 1 : 50.

Heroine forms spheroidal crystals with potassium ferrocyanide in hydrochloric acid solution only when the concentration of the alkaloid is very high. These crystals often do not appear for five minutes. With vigorous scratching there are sometimes obtained hexagonal plates belonging to the hexagonal system. Plate 2, fig. 1.

HYDRASTINE

Sensitivity, 1 : 700.

Hydrastine forms with potassium ferrocyanide in hydrochloric acid solution white, spheroidal crystals. Isolated crystals are not present. The spheroids are polarized under crossed nicols. Plate 2, fig. 8.

QUINOLINE

Sensitivity, 1 : 800.

Quinoline yields with potassium ferrocyanide in hydrochloric acid solution lemon yellow rhombohedrons exhibiting parallel and oblique extinction. Scratching is unnecessary. The crystals are very characteristic. Plate 2, fig. 9.

SPARTEINE

Sensitivity, 1 : 2,000.

Sparteine yields with potassium ferrocyanide in hydrochloric acid solution characteristic, colorless rhombs exhibiting symmetrical extinction under crossed nicols. Scratching aids in the crystal formation. Plate 2, fig. 10.

STOVAINE

Sensitivity, 1 : 300.

Stovaine yields with potassium ferrocyanide in hydrochloric acid solution rosettes of needles usually radiating from a solid mass at the center. The individual crystals exhibit parallel extinction under crossed nicols. The crystals tend to form first at the edge of the drop. Plate 2, fig. 11.

STRYCHNINE

Sensitivity, 1 : 20,000.

Potassium ferrocyanide affords a very sensitive test for strychnine. In hydrochloric acid solution this reagent yields with strychnine long, slender needles, or spear-shaped crystals with serrated edges (Plate 2, fig. 12). Hemimorphic triangular plates are sometimes formed. Under crossed nicols the long crystals exhibit oblique extinction. When the concentration of the strychnine is high but very little reagent is added, the true form of the compound sometimes comes out on scratching. These are small rhombic plates exhibiting symmetrical extinction under crossed nicols.

VERATRINE

Sensitivity, 1 : 100.

The white amorphous precipitate obtained when potassium ferrocyanide is added to a hydrochloric acid solution of veratrine yields crystals only with great difficulty. The crystals formed are imperfect and might not be recognized if polarized light were not used. Under crossed nicols they polarize strongly. The test, however, is not a satisfactory one.

SUMMARY

1. Thirteen of forty of the common alkaloids yield crystalline precipitates with potassium ferrocyanide in hydrochloric acid solution. These precipitates are sufficiently characteristic to be used as corroborative identification tests.

2. The tests can be applied to very minute amounts of material.

3. Potassium ferrocyanide is a satisfactory microchemical reagent for the distinction of cinchonidine, cinchonine, and quinine.

4. Brucine and strychnine are readily distinguished by this reagent.

5. Cocaine can be distinguished from β-eucaine, stovaine, and heroine by the potassium ferrocyanide test.

6. The sensitivity of the potassium ferrocyanide test for the various alkaloids has been determined.

ILLUSTRATIONS

Crystals of alkaloids obtained with potassium ferrocyanide and hydrochloric acid. The figures 1 : 50, etc., signify the dilutions at which the respective crystals were produced. Magnification of microphotographs, × 50.

PLATE 1

FIG. 1. β-eucaine, 1 : 50.
2. Brucine, 1 : 400.
3. Cinchonidine, 1 : 200.
4. Cinchonine, 1 : 300.
5. Cocaine, 1 : 300.
6. Coniine, 1 : 25.

PLATE 2

FIG. 7. Heroine, 1 : 25.
8. Hydrastine, 1 : 400.
9. Quinoline, 1 : 400.
10. Sparteine, 1 : 500.
11. Stovaine, 1 : 200.
12. Strychnine, 1 : 5,000.

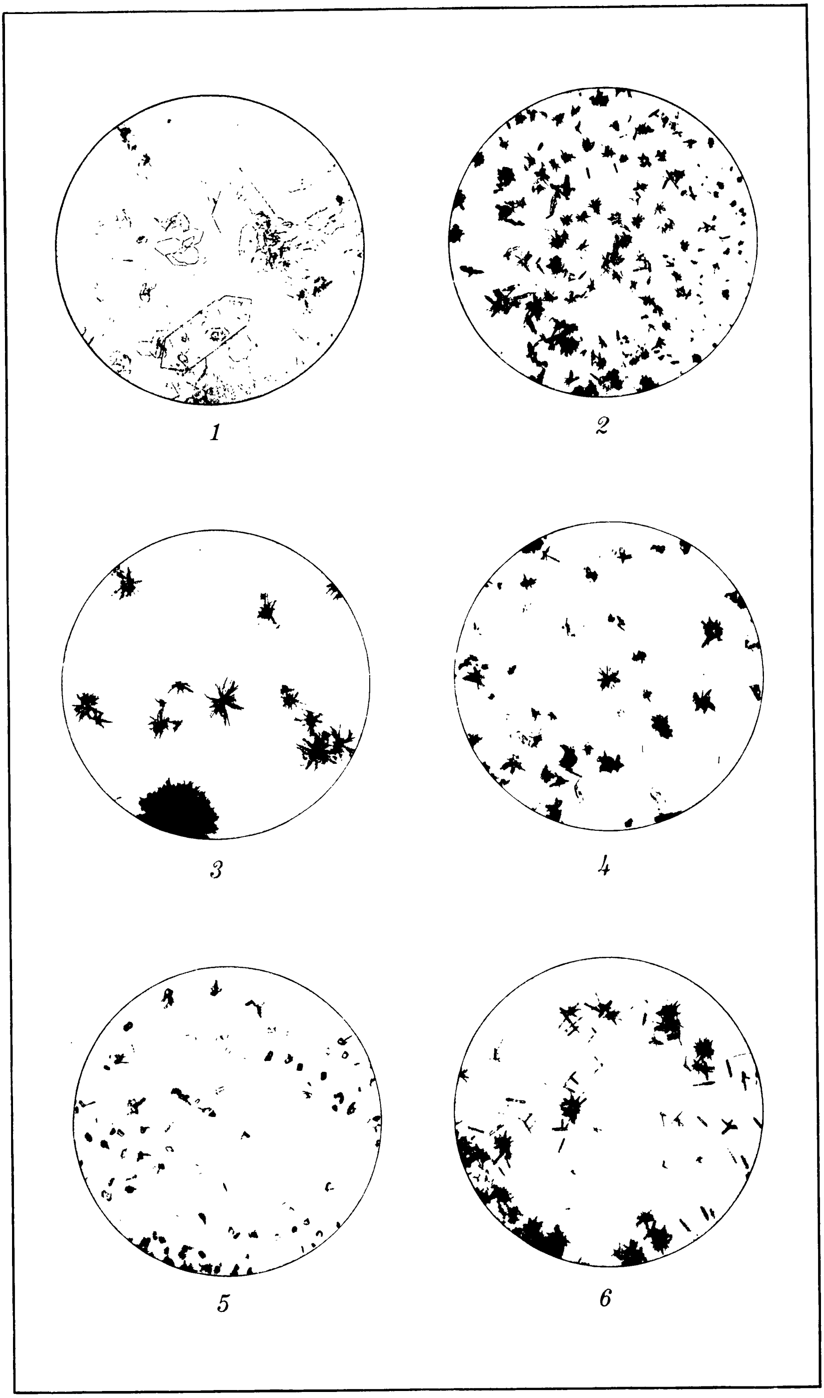
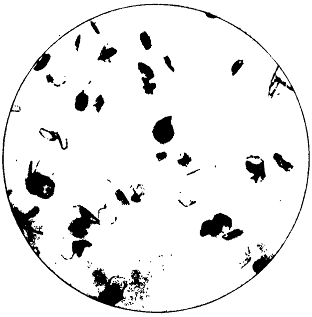


PLATE 1.



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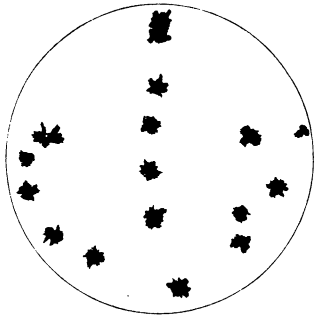

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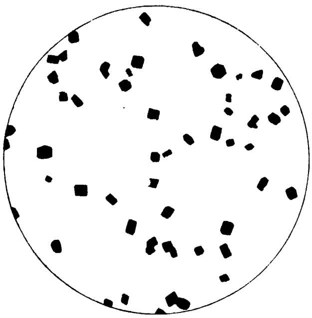

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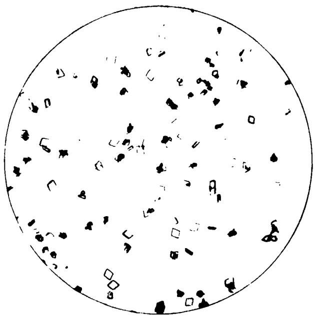

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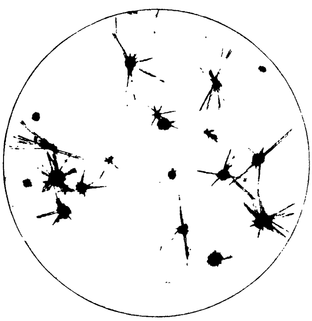

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PLATE 2.

HOOKWORM DISEASE: A CLINICAL ENTITY IN THE PHILIPPINE ISLANDS

By CHARLES N. LEACH,[1] BENJAMIN SCHWARTZ,[2] and FLORENCE DIXON LEACH

with the coöperation of

FRANK G. HAUGHWOUT[3]

TWO PLATES AND ONE TEXT FIGURE

The observations recorded in this paper were made incidentally to a brief inquiry into the incidence of hookworm infestation in the country adjacent to the city of Cebu, Cebu Island, Philippine Islands (fig. 1). They are designed formally to record the existence of hookworm disease in the Philippines because, strangely enough, this appears not to have been done in the past. To a considerable degree, the failure to record its existence probably has been the result of preconceived ideas regarding the behavior of Filipinos under the influence of hookworm infestation that have been gained from data of an unconvincing nature. In justice to the medical men working in and about Cebu, it must be said that they have recognized the condition for many years. Moreover, it should be recalled that organized survey work in tropical diseases practically ceased in 1915, at which time more-accurate methods of determining hookworm incidence were displacing the old hit-or-miss methods. As a result, the impression has been gained that the incidence of hookworm infestation in the Islands is less than 20 per cent, and that the Filipinos suffer little, if any, inconvenience from the worms they harbor; in other words, that hookworm disease is nonexistent in the Philippine Islands.

Within the past few years, however, smaller studies have been conducted in and about Manila, extending to small groups of men from certain provinces in various parts of the Archipelago. These studies have shown rather convincingly that the incidence of hookworm infestation can be expected to vary from 40 to 90 per cent in certain of the rural districts. In papers to

[1] Of the International Health Board.

[2] Of the University of the Philippines; assigned to duty with the Philippine Health Service.

[3] Of the Bureau of Science, Manila.

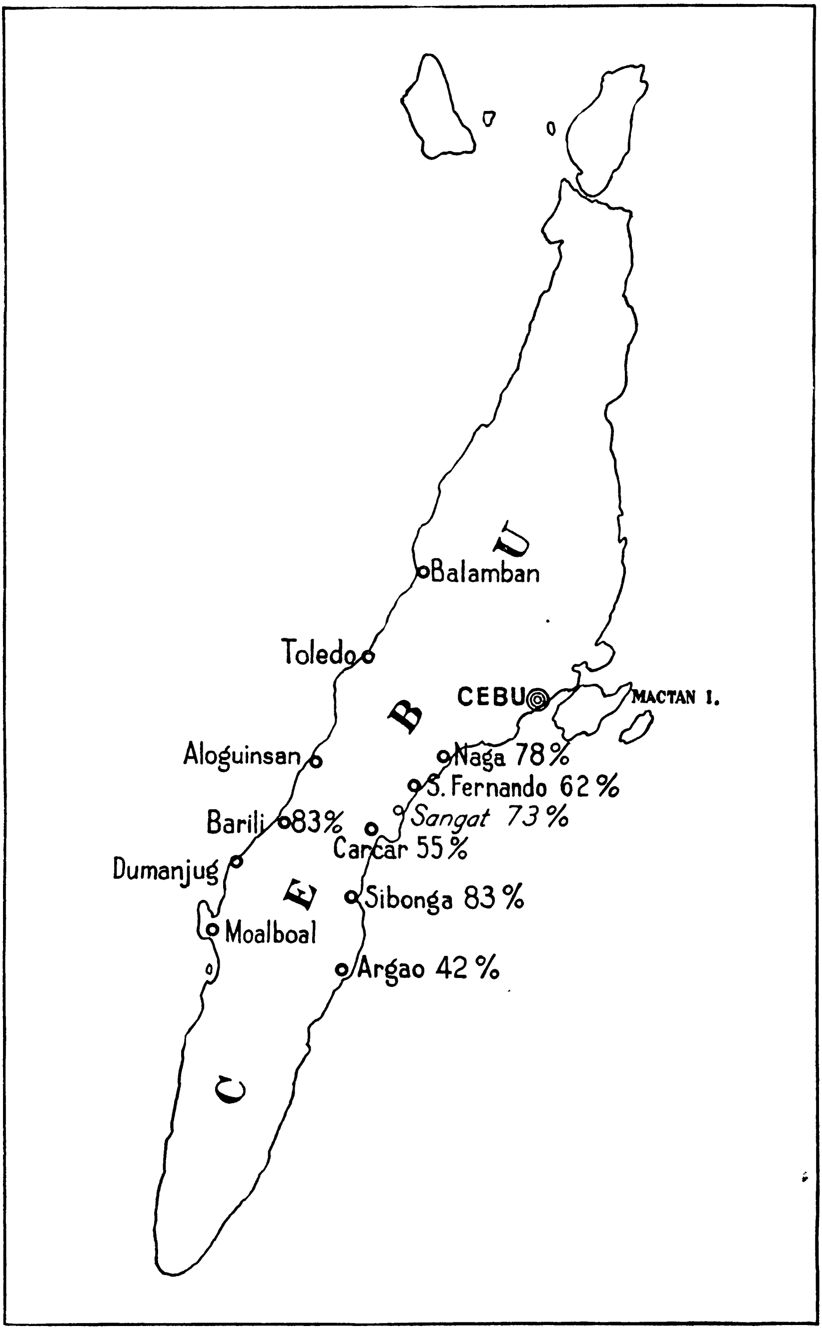

FIG. 1. Cebu Island.

be published in the near future, we shall present figures in support of this statement. We shall, at the same time, endeavor to explain how some of the misconceptions we have mentioned have arisen. It is our intent in this paper to limit our discussion to hookworm disease in Cebu.

During the survey on Cebu we were early impressed by the number of persons presenting themselves for examination and treatment who plainly were suffering from marked anæmia and, in many instances, pronounced œdema. Many of them were forced to rest in chairs after mounting the stairs that led to the improvised laboratory, until they could recover from the very obvious dyspnœa and exhaustion produced by even this slight exertion.

Although the general picture presented by these people indicated that they were suffering from hookworm disease, it seemed to us desirable, in view of the prevailing skepticism, to inquire more thoroughly into their actual physical condition.

This we were able to do through the courtesy of Dr. Augusto Villalon, director of the Southern Islands Hospital, in the city of Cebu, who admitted our patients to his institution and placed all his facilities at our disposal. We desire at this time to record our appreciation of the assistance rendered to us by Doctor Villalon and his staff.

Our time at Cebu was limited, so it was not possible to make an intensive study of the cases. We feel however that, incomplete as our observations are, they establish the existence of hookworm disease on Cebu Island beyond a reasonable doubt.

A few of the more-striking cases that we found at Carcar were sent to the Southern Islands Hospital; others were found in the hospital [4] so that, without any trouble we found eleven cases of seemingly typical hookworm disease. These were all we could handle in the time at our disposal.

Each subject was given a thorough physical examination, the blood and urine [5] were studied, and the fæces were checked to

[4] Of one hundred twenty-five patients admitted to the Southern Islands Hospital during the month of November, 1922, forty-four, or 35 per cent, were hookworm positive. These figures are based on ordinary study of cover-glass preparations, no concentration having been used. Moreover, the greater number of these positives are represented by patients with obvious anæmia, which led to special examination of their fæces for hookworm ova.

[5] No pathological elements were found in any of the specimens of urine obtained from these patients, so no further allusion will be made to the urine.

make certain that each subject was infested with hookworms. In no instance was evidence secured of the existence of renal disease, malaria, filariasis, or beriberi. Details of the physical and laboratory findings in each subject are given in a series of protocols at the end of this paper.

Of the eleven subjects studied, nine were males. Ages ranged from 10 to 68 years. Nine were laborers or had been occupied as such in the past, one was a housewife, and the other was a schoolgirl. Five patients came from Carcar, while the city of Cebu, and the towns of Liloan, Mandaue, Pardo, and San Nicolas in Cebu, and Ormoc, Leyte, each furnished one subject. Four subjects (cases 1, 2, 5, and 7) had recently undergone chenopodium treatment for hookworm infestation. We recovered small numbers of hookworms from each of these after they had been treated by us with carbon tetrachloride. All four still presented evidence of pronounced anæmia at the time we treated them.

Study of the blood of these patients showed a high-grade anæmia in all. The total erythrocyte counts ranged from 1,380,000 in a heavily infested case to 3,334,000 in a patient previously treated, from whom we recovered only three worms after carbon tetrachloride treatment.

Hæmoglobin estimations, made with the Tallquist scale, ranged from a point below the 10 per cent mark to 70 per cent, the latter in a patient who had been treated before our arrival and from whom we recovered two worms.

Differential counts were made with some difficulty because of the anæmia, and we regard our figures as only approximately correct. No blood parasites were encountered, and in this connection it should be noted that the spleen of only one subject (case 2) was palpable, and that barely at the costal margin.

No case presented an eosinophilia above 7 per cent. Five cases yielded us no eosinophiles on counting 200 leucocytes. These low figures are in harmony with the general picture noted by other observers in severe hookworm disease. Other counts are shown in Table 2.

Most of the cases presented a blood picture that might readily be mistaken for that of a primary anæmia. Marked poikilocytosis and anisocytosis were present in nearly all of the cases, and nucleated red cells were found in cases 2, 3, 5, and 9. All these details are set forth in Table 1 and appear in the protocols.

Preliminary to a discussion of the blood picture and worm counts, it should be stated that stools were collected from the

patients for the two days succeeding treatment, and screened for the recovery of the worms.

TABLE 1.—*Blood picture and worm counts in eleven cases of hookworm disease.*

Case No.	Total erythrocytes.	Hæmoglobin percentage, Tallquist.	Poikilocytosis.	Anisocytosis.	Nucleated red cells.	Eosinophiles.	Worm count after treatment.			
							Ancylostoma duodenale.	*Necator americanus.*	Macerated hookworms.	Total worms recovered.
						P. ct.				
1 [a]	3,296,000	70	—	(b)	0	0	2	0	0	2
2 [a]	3,334,000	15	+	+	4	3.0	1	3	0	3
3	1,640,000	55	+	+	8	0.5	4	99	0	103
4	2,160,000	—10	+	+	0	0	22	79	13	114
5 [a]	1,920,000	15	+	+	5	0	2	9	0	11
6	2,680,000	35	+	+	0	7.0	18	1,274	48	1,340
7 [a]	2,130,000	40	+	+	0	1.0	3	15	0	18
8	2,776,000	25	+	+	0	0	26	157	7	190
9 [c]	1,380,000	—10	+	+	1	0	(d)	(d)	(d)	(d)
10 [c]	2,700,000	45	--------	--------	--------	--------	(d)	(d)	(d)	(d)
11	1,760,000	—10	—	—	0	2	(f)	(f)	(f)	1,111

[a] Previously treated for hookworm infection.
[b] Slight.
[c] The worms from this subject were lost in the washing of the stool.
[d] No count made.
[e] Worms were passed by this subject in such a bad state of maceration they could not be counted.
[f] Record lost.

Inspection of Table 1 will show that the worm counts in cases 6 and 11 were very high. So far as we have knowledge, they are the highest that ever have been recorded in the Philippines. It is probable that the yield from case 9 was as high as, if not higher than, either of these, for great masses of worms were seen when the work of washing the stool was in progress. Unfortunately, however, a 15 per cent solution of sodium hydroxide was employed to break down a heavy deposit of thick, tenacious mucus, and the worms shrank and disappeared through the meshes of the screen as if by magic, being lost to view in a few seconds. The subject was a man, 68 years of age, who presented a very extreme picture of hookworm disease.

Cases 3, 4, and 8 present the apparently anomalous picture of a pronounced anæmia coupled with a relatively low worm count. This can be explained, so far as cases 4 and 8 are concerned, by the large proportion of ancylostomes present, amounting in case 4 to 19 per cent of the total number, and in case 8

to 13 per cent of the total number. The total worm count in case 3 is the lowest of these three cases; and, while the relative proportion of ancylostomes is lower than in the other two, it will be noted that the hæmoglobin percentage is 55 as against the —10 and 25 in cases 4 and 8, respectively. These figures represent a startlingly high ancylostome index for the Malay region, but we shall postpone our discussion of that point pending the preparation of our other paper. In passing, attention is drawn to case 6, with a total worm count of 1,340, but with a hæmoglobin percentage of 35. In this case only 18 ancylostomes were recovered.

The general physical examination of the subjects yielded information that harmonizes well with the foregoing. The family and previous personal history of the patients revealed nothing of special bearing on their condition as harborers of hookworms at the time of observation, with the exception of case 10, a girl 10 years old, to whom we shall allude in greater detail farther on.

Every case presented the gross appearance of advanced anæmia. In most instances the conjunctivæ were all but colorless. At least five of the subjects showed the dusky facies that has been styled "hookworm pallor." All showed varying degrees of emaciation from slight to pronounced, as in case 9. Œdema of the extremities was marked in five cases and one subject, case 7, presented a markedly protruberant abdomen. Hæmic murmurs, ranging from slight to pronounced, were elicited in nine subjects. In a word, all the patients were frankly sick and obviously unfit to carry out their ordinary duties, let alone hard manual labor.

One subject, case 4, was suffering from pulmonary tuberculosis in an advanced stage, and the lungs of four others were not above suspicion. There were no other findings of significance in any of the subjects.

In short, a fairly thorough clinical and laboratory study of these people failed to discover any cause for their anæmia other than the hookworms they harbored, and we have no hesitation in stating our belief that they were suffering from hookworm disease in its strict sense.

Detailed discussion of the individual cases would seem to be unnecessary. We desire, however, to direct especial attention to the protocol of case 10, because it presents, in a striking manner, one untoward phase in the problem of education in the Philippine Islands, and shows how at least one child was thwarted

in its efforts to obtain an education. How many thousand other Filipino children are similarly handicapped we cannot, of course, say at the present time. There is nothing in the picture presented by this particular child that is not perfectly familiar to those acquainted with hookworm disease in children; but it is a sad commentary on the indifference and misconception that has led to an almost total neglect of hookworm infections as a factor in the health, education, and economic welfare of the people of the Philippine Islands.

All these patients received treatment with carbon tetrachloride on the basis of 1 cubic centimeter of the drug to each 5.5 kilograms of body weight. Aside from slight dizziness and drowsiness, none of them exhibited the slightest untoward effects from the treatment. A hyper-secretion of mucus in the intestinal tract, persisting for a number of hours after the treatment, was noted in nearly every case; that will be discussed below. The actual amount of drug administered to each patient is given in the individual protocols. No delayed untoward effects from the drug were observed when all were inspected by one of us (F.G.H.) five days after treatment. At that time several of the patients were allowed to return to their homes. Case 4 was retained in the hospital, because of the advanced stage of her tuberculosis, but her condition was not noticeably modified by the treatment. Others also were detained in order that iron and arsenic might be administered under supervision, for the correction of their extreme anæmia.

Because the time was short, it was found necessary to proceed immediately with treatment, without a preliminary fast. Accordingly, a purge of magnesium sulphate was administered to each patient, the carbon tetrachloride being given as soon as the bowels moved. We believe this to have been a mistake, because the bowel movements following treatment consisted almost entirely, in nearly every case, of a large volume of mucus which we consider to have been the expression of a rather high degree of intestinal irritation, resulting from the combined action of the salts and the carbon tetrachloride.

PROTOCOLS OF CASES

CASE 1

Nemesio Unabia, male, aged 22 years; residence, Carcar, Cebu; occupation, laborer; weight, 38.5 kilograms.

This patient had been previously treated for hookworm.

Narcotics.—Alcohol and tobacco moderately.

Family history.—Father dead, cause unknown; brothers and sisters all living.

Personal history.—Dysentery at 11 years; fracture of rib at 12 years; smallpox in infancy; cholera in childhood.

Special senses.—Normal.

Skin and mucous membranes.—Visible mucous membranes very pale; conjunctivæ extremely anæmic; skin clear; does not show characteristic hookworm pallor.

Glandular system.—Inguinal glands palpable.

Pulse.—108; regular in rate and rhythm.

Heart.—A.C.D., normal; slight hæmic murmur; otherwise normal.

Lungs.—Normal except for old adhesions at the site of fracture of ribs at right lower side; adhesions in same region on the left side, also at site of old fracture.

Genito-urinary system.—Not examined.

Abdomen.—No tenderness; no masses.

Spleen and liver.—Not palpable.

Nervous system, osseous system, muscles, and joints.—Normal.

Blood findings:

Total erythrocytes, 3,296,000.
Hæmoglobin, 70 per cent.
Polymorphonuclears, 79 per cent.
Eosinophiles, none.
Lymphocytes, 20 per cent.
Large mononuclears, 1 per cent.
Poikilocytosis, —.
Anisocytosis, slight.

Treatment with 7 cubic centimeters of carbon tetrachloride.

Worms recovered on screening, *Ancylostoma duodenale*, females, 2.

CASE 2

Juan Pepito, male, aged 25 years; residence, Liloan, Cebu; occupation, laborer; weight, 52.5 kilograms.

This patient had been treated for hookworm infection on two previous occasions, receiving 15 minims of oil of chenopodium each time.

Narcotics.—Alcohol and tobacco moderately.

Family history.—Mother dead, cause unknown; one brother died of "fever."

Personal history.—"Fever" of two days' duration four years ago; nothing else of significance.

Special senses.—Normal.

Skin and mucous membranes.—Considerable anæmia; oral mucous membranes especially anæmic; skin of palms, soles, and fingers extremely anæmic; depigmentation of skin; no œdema.

Glandular system.—Right epitrochlear glands and inguinal glands palpable.

Pulse.—62; regular in rate and rhythm.

Heart.—A.C.D., not increased; short hæmic murmur, best heard over mitral valve; otherwise normal.

Lungs.—Sounds are normal.

Genito-urinary system.—Normal.

Abdomen.—No tenderness; no masses.

Spleen.—Palpable at costal margin to the right of midclavicular line.

Liver.—Not palpable.

Nervous system, osseous system, muscles, and joints.—Normal.

Blood findings:

Total erythrocytes, 3,334,000.
Hæmoglobin, 15 per cent.
Polymorphonuclears, 50 per cent.
Eosinophiles, 3 per cent.
Lymphocytes, 47 per cent.
Poikilocytosis (marked), +.
Anisocytosis (marked), +.

Treatment with 9.4 cubic centimeters of carbon tetrachloride.

Worms recovered on screening:

Ancylostoma duodenale, male, 1.
Necator americanus, females, 2.

CASE 3

Juan Seno, male, aged 25 years; residence, Mandaue, Cebu; occupation, laborer; weight, 49.5 kilograms.

Narcotics.—Alcohol in moderation.

Family history.—One brother dead, cause unknown; one sister dead, cause unknown.

Personal history.—Smallpox in childhood; operation for hydrocele recently; still under treatment.

Special senses.—Normal.

Skin and mucous membranes.—Visible mucous membranes extremely anæmic; conjunctivæ extremely anæmic; palms and finger tips very anæmic; no œdema.

Glandular system.—Inguinal glands palpable.

Pulse.—78; regular in rate and rhythm.

Heart.—A.C.D., and sounds are normal.

Lungs.—Impairment of resonance over right posterior lobe; breath sounds prolonged; roughened expiration over areas of impaired resonance; no râles; no cough.

Genito-urinary system.—Normal.

Abdomen.—No tenderness; no masses.

Spleen and liver.—Not palpable.

Nervous system, osseous system, muscles, and joints.—Normal.

Blood findings:

Total erythrocytes, 1,640,000.
Hæmoglobin, 55 per cent.
Polymorphonuclears, 72.5 per cent.
Eosinophiles, 0.5 per cent.
Lymphocytes, 27 per cent.
Poikilocytosis, +.
Anisocytosis, +.

Treatment with 9.0 cubic centimeters of carbon tetrachloride.

Worms recovered on screening:

Ancylostoma duodenale, females, 4.

Necator americanus:

Males, 54.

Females, 45.

Ascaris (immature), 2.

Oxyuris, 2.

CASE 4

Pelagia Laputan, female, aged 50 years; residence, Carcar, Cebu; occupation, housewife; weight, 36.8 kilograms.

Patient is extremely emaciated. There is considerable swelling over the malar region.

Narcotics.—Tobacco and alcohol in moderation.

Family history.—Father and mother dead, cause unknown; three brothers dead: one murdered, one of infection of the foot, one cause unknown; two sisters dead, one burned, one of "fever."

Personal history.—Smallpox in infancy.

Special senses.—Considerable impairment of hearing, bilateral; slight impairment of sight.

Skin and mucous membranes.—Visible mucous membranes show considerable anæmia; conjunctivæ very anæmic; skin glossy and considerably stretched over upper and lower extremities, hands, and feet as a result of œdema.

Glandular system.—No palpable glands.

Pulse.—68; regular in rate and rhythm.

Heart.—A.C.D., normal; slight hæmic murmur.

Lungs.—Considerable impairment of resonance in right upper lobe, posterior; many fine, crepitant râles, right upper anterior; left chest, anterior and posterior, shows hyper-resonance; emphysema; tuberculosis of right upper lobe.

Abdomen.—Lower half protuberant; no tenderness; no masses.

Spleen and liver.—Not palpable.

Nervous system, osseous system, muscles, and joints.—Not examined.

Blood findings:

Total erythrocytes, 2,160,000.

Hæmoglobin, 10 per cent.

Polymorphonuclears, 86 per cent.

Eosinophiles, none.

Lymphocytes, 14 per cent.

Poikilocytosis, +.

Anisocytosis, +.

Treatment with 6.7 cubic centimeters of carbon tetrachloride.

Worms recovered on screening:

Ancylostoma duodenale:

Males, 13.

Females, 9.

Necator americanus:

Males, 32.

Females, 47.

Macerated hookworms, 13.

CASE 5

Getulio Umban, male, aged 28 years; residence, Carcar, Cebu; occupation, laborer; weight, 45.6 kilograms.

This patient had been previously treated for hookworm.

Narcotics.—Alcohol and tobacco moderately.

Family history.—All members of family alive and well.

Personal history.—Mumps at 8 years; smallpox in childhood.

Special senses.—Normal.

Skin and mucous membranes.—Visible mucous membranes extremely anæmic; conjunctivæ very anæmic; palms and finger tips very pale; ashen gray appearance of skin of face; smallpox pittings.

Glandular system.—Inguinal glands palpable.

Pulse.—84; regular in rate and rhythm.

Heart.—A.C.D., slightly increased to left; pronounced hæmic murmur.

Lungs.—Normal.

Genito-urinary system.—Right hydrocele; has been operated upon.

Abdomen.—No tenderness; no masses.

Spleen and liver.—Not palpable.

Nervous system, osseous system, muscles, and joints.—Normal.

Blood findings:

Total erythrocytes, 1,920,000.
Hæmoglobin, 15 per cent.
Polymorphonuclears, 71 per cent.
Eosinophiles, none.
Lymphocytes, 29 per cent.
Poikilocytosis, +.
Anisocytosis, +.
Nucleated red cells, 5.

Treatment with 8.3 cubic centimeters of carbon tetrachloride.

Worms recovered on screening:

Ancylostoma duodenale:
Male, 1.
Female, 1.
Necator americanus, females, 9.

CASE 6

Meliton Montesa, male, aged 27 years; residence, Ormoc, Leyte; occupation, laborer; weight, 51.1 kilograms.

Narcotics.—Alcohol in moderation.

Family history.—Mother died of tuberculosis; father living; three brothers dead, one of tuberculosis, one of influenza, and one of dysentery; one sister died of unknown cause.

Personal history.—"Fever" of five days' duration in 1922; denies other illnesses.

Special senses.—Normal.

Skin and mucous membranes.—Visible mucous membranes and conjunctivæ quite anæmic; skin of palms and finger ends very pale; ashen gray pallor of face; marked œdema of feet and ankles.

Glandular system.—Inguinal glands palpable.
Pulse.—82; regular in rate and rhythm.
Heart.—A.C.D., normal; soft hæmic murmur over mitral valve.
Lungs.—Especially clear, in spite of family history.
Genito-urinary system.—Normal.
Abdomen.—No tenderness; no masses.
Spleen and liver.—Not palpable.
Nervous system, osseous system, muscles, and joints.—Normal.
Blood findings:
  Total erythrocytes, 2,680,000.
  Hæmoglobin, 35 per cent.
  Polymorphonuclears, 69.5 per cent.
  Eosinophiles, 7 per cent.
  Lymphocytes, 23.5 per cent.
  Poikilocytosis, +.
  Anisocytosis, +.
Treatment with 9.3 cubic centimeters of carbon tetrachloride.
Worms recovered on screening:
  Ancylostoma duodenale:
    Males, 8.
    Females, 10.
  Necator americanus:
    Males, 658.
    Females, 616.
  Macerated hookworms, 48.
  Oxyuris, 26.

CASE 7

Sebastian Dayap, male, aged 20 years; residence, Inayawan, Pardo, Cebu; occupation, laborer; weight, 34.6 kilograms.

This patient had been previously treated for hookworm. He is extremely emaciated, with protuberant abdomen.

Narcotics.—Alcohol in moderation.

Family history.—Father dead, cause unknown; mother living; two brothers and three sisters living.

Personal history.—Smallpox in childhood.

Special senses.—Normal.

Skin and mucous membranes.—Conjunctivæ and visible mucous membranes, palms, and finger tips extremely anæmic; dusky pallor of face; hookworm facies; marked œdema of lower extremities.

Glandular system.—No palpable glands.

Pulse.—100; regular in rate and rhythm.

Heart.—A.C.D., normal; short, soft hæmic murmur.

Lungs.—Antero-posterior diameter somewhat increased; entire chest hyper-resonant; prolonged expiration; breath sounds normal.

Genito-urinary system.—Normal.

Abdomen.—No tenderness; no masses.

Spleen and liver.—Not palpable.

Nervous system, osseous system, muscles, and joints.—Normal.

Blood findings:
- Total erythrocytes, 2,130,000.
- Hæmoglobin, 40 per cent.
- Polymorphonuclears, 73.5 per cent.
- Eosinophiles, 1 per cent.
- Lymphocytes, 25.5 per cent.
- Poikilocytosis, +.
- Anisocytosis, +.

Treatment with 6.3 cubic centimeters of carbon tetrachloride.

Worms recovered on screening:
- *Ancylostoma duodenale,* females, 3.
- *Necator americanus:*
  - Males, 6.
  - Females, 9.

CASE 8

Macario Lapingkao, male, aged 24 years; residence, Carcar, Cebu; occupation, laborer; weight, 40.1 kilograms.

Narcotics.—Alcohol and tobacco moderately.

Family history.—Three brothers and one sister, all living.

Personal history.—Smallpox in infancy; states he has been pale ever since he was a boy.

Special senses.—Normal.

Skin and mucous membranes.—Conjunctivæ extremely anæmic; visible mucous membranes very anæmic; palms and finger tips anæmic; the man's face exhibits the characteristic hookworm pallor.

Glandular system.—Inguinal glands palpable.

Pulse.—96; regular in rate and rhythm.

Heart.—A.C.D., normal; very pronounced hæmic murmur.

Lungs.—Normal.

Genito-urinary system.—Normal.

Abdomen.—No tenderness; no masses.

Spleen and liver.—Not palpable.

Nervous system, osseous system, muscles, and joints.—Normal.

Blood findings (100 cells counted):
- Total erythrocytes, 2,776,000.
- Hæmoglobin, 25 per cent.
- Polymorphonuclears, 74 per cent.
- Eosinophiles, none.
- Lymphocytes and mononuclears, 26 per cent.
- Poikilocytosis, +.
- Anisocytosis, +.

Treatment with 7.3 cubic centimeters of carbon tetrachloride.

Worms recovered on screening:
- *Ancylostoma duodenale:*
  - Males, 9.
  - Females, 17.
- *Necator americanus:*
  - Males, 57.
  - Females, 100.
- Macerated hookworms, 7.

CASE 9

Ruperto Laputan, male, aged 68 years; residence, Carcar, Cebu; occupation, laborer; weight, 44.0 kilograms.

Narcotics.—Alcohol moderately.

Family history.—Three brothers dead, cause unknown; one brother living; one sister died of burns; three sisters living.

Personal history.—Fracture of left leg at 18 years; smallpox at 12 years; abscess of back at 17 years.

Special senses.—Slight impairment of hearing, bilateral; decided impairment of vision; marked arcus senilis.

Skin and mucous membranes.—Conjunctivæ very anæmic; mucous membranes of mouth very pale; palms and finger tips very anæmic; the skin is rough and wrinkled, and lies in loose folds, indicating former adiposity; considerable œdema of the lower extremities.

Glandular system.—Normal.

Pulse.—64; regular in rate and rhythm.

Heart.—A.C.D., normal; prolonged soft hæmic murmur heard over entire A.C.D.

Lungs.—Entire chest is hyper-resonant excepting the right upper posterior; impaired resonance at right upper posterior; many coarse and fine crepitant râles; moist mucous râles?

Genito-urinary system.—Not examined.

Abdomen.—No tenderness; no masses.

Spleen.—Not palpable.

Liver.—Palpable at costal margin.

Nervous system, osseous system, muscles, and joints.—Normal.

Blood findings:

Total erythrocytes, 1,380,000.
Hæmoglobin, 10 per cent.
Polymorphonuclears, 76.5 per cent.
Eosinophiles, none.
Lymphocytes, 23.5 per cent.
Poikilocytosis, +.
Anisocytosis, +.
Nucleated red cells, 1.

Treatment with 8.0 cubic centimeters of carbon tetrachloride.

Worms were lost on screening.

CASE 10

Constancia Mendoza, female, aged 10 years; residence, Cebu, Cebu; occupation, student; weight, 24.2 kilograms.

This child was born in Carcar and lived there for eight years.

Symptoms on admission.—Marked paleness, general weakness, dyspnœa and fatigue on slight exertion.

Narcotics.—None.

Family history.—Father and mother living and well; three out of eight children died of smallpox; others are living.

Personal history.—The patient is the fifth child of the family; she had measles and smallpox in early childhood; no other illnesses of importance; the present illness began two years ago with gradually developing pallor

and loss of strength; she attended school for only one year and was obliged to leave school because she was easily fatigued by the journey to and from school; for the last four months she has suffered from persistent constipation, her bowels moving on an average only once a week; on admission she was afebrile and appeared normal except as noted; appetite is fair, sleep normal, bowel movements constipated; her general development and nourishment are fair.

Special senses.—Normal.

Skin and mucous membranes.—Conjunctivæ markedly pale; lips, gums, and buccal mucous membranes anæmic; no hæmorrhage; marked pallor of skin of extremities.

Pulse.—Not taken.

Heart.—A.C.D., normal; sounds normal; no murmurs.

Lungs.—Normal.

Genito-urinary system.—Not examined.

Neck.—No adenitis; bruit du diable heard over right side.

Abdomen.—No tenderness; no masses.

Spleen and liver.—Not palpable.

Nervous system.—Normal.

Blood findings:

Total erythrocytes, 2,700,000.
Hæmoglobin, 45 per cent.
Differential count not made.

Treatment with 4.4 cubic centimeters of carbon tetrachloride.

Worms were destroyed by maceration, only three being recovered, as follows:

Ancylostoma duodenale, male, 1.
Necator americanus, female, 2.

Bowel movements following treatment were few in number and very scanty in quantity. The patient showed no ill effects from the treatment, however.

CASE 11

Pedro Sabay, male, aged 37 years; residence, San Nicolas, Cebu; occupation, laborer; weight, 49.5 kilograms.

Narcotics.—Alcohol in moderation.

Family history.—Mother and father dead, cause unknown; one brother drowned; two sisters dead, one of cholera, one of bubonic plague.

Personal history.—Mild smallpox at 8 years; unknown illness at 12 years.

Special senses.—Normal.

Skin and mucous membranes.—Conjunctivæ and buccal mucous membranes extremely pale; palms and finger tips show extreme anæmia; ashen gray appearance of face, hookworm pallor; irregular white scars over shins, due to accident.

Glandular system.—Inguinal glands palpable.

Pulse.—68; regular in rate and rhythm.

Heart.—A.C.D., normal; pronounced hæmic murmur.

Lungs.—Impaired resonance, right posterior upper; respiratory sounds slightly prolonged over right upper; no râles.

Genito-urinary system.—Normal.

Abdomen.—No tenderness; no masses.
Spleen and liver.—Not palpable.
Nervous system, osseous system, muscles, and joints.—Normal.
Blood findings:
    Total erythrocytes, 1,760,000.
    Hæmoglobin, —10 per cent.
    Polymorphonuclears, 71.5 per cent.
    Eosinophiles, 2 per cent.
    Lymphocytes, 25 per cent.
    Large mononuclears, 1.5 per cent.
Treatment with 9.0 cubic centimeters of carbon tetrachloride.
Worms recovered on screening, 1,111.
Differential worm count lost.

ILLUSTRATIONS

[Photographs by C. N. Leach. Map drawn by M. Ligaya.]

PLATE 1

FIG. 1. Case 4. Note swelling over malar region, emaciation of torso, and marked œdema of forearms and lower extremities.

2. Case 7. Note puffiness of face, emaciation of body and upper extremities, and œdema of the legs.

PLATE 2

FIG. 1. Case 2. Previously treated patient, still positive for hookworm and showing protuberant abdomen.

2. Group of subjects at Carcar, all showing symptoms of advanced hookworm disease. Arrow points to case 9, in the group treated at the Southern Islands Hospital.

TEXT FIGURE

FIG. 1. Map of Cebu Island, showing towns surveyed.

Fig. 1. Case 4.

Fig. 2. Case 7.

PLATE 1.

Fig. 1. Case 2.

Fig. 2. Group at Carcar.

PLATE 2.

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THE PHILIPPINE JOURNAL OF SCIENCE

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A REVIEW OF THE EELS OF THE PHILIPPINE ARCHIPELAGO

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ELEVEN PLATES AND FOURTEEN TEXT FIGURES

This review contains descriptions of all the eels, or apodal fishes, known from the Philippine Archipelago. Two orders are here treated, although the first order may have no real affinity with the true eels. The first order contains two genera and two species; the second order, twenty-three genera and sixty-one species, including one new genus and eight new species. The eel-like catfishes, blennies, and gobies, more or less abundant in the streams and along the coasts of the Philippines, are not here considered.

The eels form a readily recognizable group, although until the skeletal characters are better known we cannot be certain that we have not grouped together some unrelated families under the larger of the two orders here treated. While all eels are more or less edible, some of them, especially the Anguillidæ, or fresh-water eels, and the congers, are much esteemed and form an important part of the food supply of the Islands. Eels are caught with nets, in the ever-present *baclad*, or fish corral, and with hook and line, and they occur in large numbers at times in the *bañgos* fishponds about Manila Bay, but most of them are captured with some form of *bobo*, or woven bamboo trap.

As would naturally be surmised, the eels of the Philippines are East Indian, most of the species occurring from India to the South Sea Islands. In spite of their great abundance about the

coral reefs, our knowledge of the distribution of many species is still very defective. Certain genera have been neglected by collectors, while the fishermen fear and, therefore, make little attempt to catch the large, fiercely biting, snakelike morays.

In preparing this paper Jordan's Genera of Fishes and The Fishes of the Indo-Australian Archipelago by Weber and Beaufort have been of great assistance. No attempt has been made to make the synonymy complete in all respects.

Order SYNBRANCHIA

This group of serpentlike fishes is of degraded type and unknown relationships, but is probably closely related to the Apodes, having the body naked or with minute cycloid scales.

The mouth is of the ordinary fish type, the maxillary, premaxillary, and palatine bones being well developed, while in the typical forms the shoulder girdle is joined to the head; in one family, the Amphipnoidæ of India, it is distinct from the skull as in the true eels. There are no paired fins, while the rudimentary vertical fins are reduced to mere folds of skin. The gills may be well developed or they may be rudimentary; in the latter case there is an accessory breathing apparatus, consisting of a respiratory air sac or sacs in the neck, behind the head and communicating with the gill cavity. The gill openings are confluent in a single ventral slit. There is no air bladder, and the stomach has neither a blind sac nor pyloric cæcæ. The skull is solid, and the bones are firmly united; the vertebræ are numerous, unmodified, with ribs present; the anal opening is far back in the posterior half, and the ovaries have oviducts.

This order includes a small number of eel-like fishes widely distributed in tropical fresh and brackish waters and along the coasts of warm seas. Four families of divergent structure are known; representatives of two of them occur in the Philippines. They are both scaleless, without accessory breathing apparatus, and have the shoulder girdle attached to the skull.

Key to the families.

a^1. Gill arches three, gills rudimentary .... **Monopteridæ.**
a^2. Gill arches four, gills well developed .... **Synbranchidæ.**

MONOPTERIDÆ

RICE-FIELD EELS

Body elongate, naked, tail short and tapering to a point; margin of upper jaw formed by premaxillaries, the maxillaries well

developed but lying behind and parallel with them; lips thick; palatine teeth small, in a narrow band; gill membranes nearly entirely united to isthmus by a median septum which divides gill opening; gill arches three, with rudimentary gill fringes, and moderately wide slits between them; dorsal and anal fins reduced to mere folds; vertebræ $100 + 88 = 188$.

Eel like fishes of the rice ditches, rivers, and brackish water, from Burma and the East Indies to North China, Korea, Formosa, and the Riu Kiu Islands.

Genus FLUTA Bloch and Schneider

Fluta BLOCH and SCHNEIDER, Syst. Ichth. (1801) 565.

Monopterus Lacépède is preoccupied by *Monopteros* Volta, Ichth. Veronese (1796), a genus of fossil fishes.

Characters of the genus included above.

Fluta alba (Zuieuw).

Muræna alba ZUIEUW, Nov. Act. Acad. Sci. Petropol. 7 (1789) 299, pl. 7, fig. 2.

Monopterus javanois LACÉPÈDE, Hist. Nat. Poiss. 2 (1798) 139.

Monopterus javanensis SCHNEIDER, Syst. Ichth. (1801) 565, after Lacépède; BLEEKER, Atlas Ichth. Muræn. 4 (1864) 118, pl. 47, fig. 1; GÜNTHER, Cat. Fishes Brit. Mus. 8 (1870) 14.

Monopterus albus JORDAN and SNYDER, Proc. U. S. Nat. Mus. 23 (1901) 838, Riu Kiu Islands; WEBER and BEAUFORT, Fishes Indo-Austr. Arch. 3 (1916) 413, figs. 210 and 211.

Head 13 in length, its depth greater than that of body, 1⅔ in its length; depth 22 (17 to 26) in length. Jaws heavy, the lower shorter; maxillary 2 in head; teeth small, mostly uniserial. Eye very small, over middle of maxillary. Gill openings inferior, confluent in a semicircular slit. Tail very short, pointed, 2¾ in rest of body.

Dorsal fin very low, rayless, beginning close behind vent. Anal similar, very indistinct, about half length of dorsal; no pectorals or ventrals. Color in spirits blackish olive, with traces of darker and paler streaks and mottlings, a dark cross band behind head; in life with yellowish streaks and dark dots above.

Length 1 to 2 feet.

The above description is copied from Jordan and Snyder's Apodal Fishes of Japan. No specimens have been seen by me from the Philippines, but the species is recorded by Fowler.[1] His specimen is in the Philadelphia Commercial Museum and is merely labeled "Philippine Islands."

According to Weber and Beaufort "this fish is capable of living a considerable time out of water and of burying itself in the mud when the water is drying up."

[1] Copeia No. 58 (June 18, 1918) 62.

Undoubtedly occurs in the Philippines in the fresh-water streams and rice paddies of the larger islands.

SYNBRANCHIDÆ

General characters as in the Monopteridæ, but differing in some important particulars.

Instead of three, there are four branchial arches, bearing well-developed gills with wide slits between them, while the gill membranes are free from the isthmus. There are six branchiostegals. Teeth of maxillaries, vomer, and palatine in one to several rows, those of the vomer-palatine region in an arched band. There is no accessory breathing sac. Eye is small, covered by skin. The dorsal and anal are reduced to rayless folds of skin.

Genus **SYNBRANCHUS** Bloch

Synbranchus BLOCH, Naturgesch. der Ausl. Fische **9** (1795) 86; WEBER and BEAUFORT, Fishes Indo-Austr. Arch. **3** (1916) 415.

Characters of the genus included above. Occurring throughout the rainy tropics, in both fresh and brackish water.

Synbranchus bengalensis (McClelland).

Ophisternon bengalensis MCCLELLAND, Apod. Fishes Bengal, Calcutta Journ. Nat. Hist. **5** (1845) 197, 200, pl. 2, figs. 1 and 2.

Synbranchus bengalensis BLEEKER, Atlas Ichth. Muræn. **4** (1864) 119, pl. 48, fig. 1; WEBER and BEAUFORT, Fishes Indo-Austr. **3** (1916) 416, fig. 213.

Synbranchus bengalensis GÜNTHER, Cat. Fishes Brit. Mus. **8** (1870) 16; DAY, Fishes of India (1878–88) pl. 167, fig. 2.

Depth a little over 21 to 30 in total length, head 8.75 to almost 12; tail 3.25 to a little more than 4 in total length, and not "nearly 4 times in head and trunk" as stated by Weber and Beaufort; eye small, near tip of snout, and 15 to more than 20 in length of head; mouth oblique, 3 to 3.5 in head, with lips folded back over both jaws, not merely the lower one as stated by authors; snout short, blunt, about one-third the cleft of mouth; posterior nostrils small oval to circular openings on top of head and back of pupil of eye; anterior nostrils minute openings in tip of snout; fins usually low and inconspicuous, the dorsal commencing slightly in advance of the gill opening; lateral line conspicuous.

The cylindrical body elongate and snakelike, with anal opening very far back; tail strongly compressed, tapering, and short.

The color of living specimens varies from very dark olive green to very dark wine red, with belly and chin paler.

Alcoholic specimens are generally uniform dark purplish blackish, but may be very dark brown or reddish brown. A number of preserved specimens examined have the tail so strongly compressed as to present a marked contrast to the body, with broad, white-margined dorsal and anal fins, so that it greatly resembles in appearance the tail of certain salamanders; the height of the dorsal may be from a third to a half of the tail beneath.

I have examined several hundred living specimens and have kept a number in both salt- and fresh-water aquaria. They are apparently very sluggish animals, and remain motionless for hours, either buried in the mud or with the head and half or more of the body raised high above the bottom, much as is the habit of "tomato worms" and other large sphingid larvæ. In the Sambali language they are called *talé-rec,* because of this habit. In many Philippine languages they are called *palos* or *palus,* a word applied to all small eels, especially those of brackish water, but not ordinarily applied to the fresh-water eels. They love to lie partially buried in the mud, with only the tail visible. When disturbed they usually swim off tail first, a procedure which I regard as a protective device, since an enemy would naturally seize upon the wiggling tail. If the tip of the tail were bitten off, the head and trunk, more or less buried in the mud, would easily escape.

I have also examined numerous preserved specimens in the collections of the University of the Philippines, the Philippine Normal School, the Ateneo de Manila, and of Mr. Alejo Arce. Most of them are from Manila Bay, but Mr. Arce's specimen is from Baybay Creek, a tributary of Lake Buhi, while some of those in the University of the Philippines collection are from Apo Reef, west of Mindoro.

This species is evidently abundant and widely distributed in the Philippines but, in common with a number of fresh-water fishes, has been overlooked by collectors. It was first collected here by Jagor in Quingua River near Calumpit, Pampanga.[2] Casto De Elera reported it from Navotas, Manila Bay, while Günther also mentions a specimen in the British Museum as being from the Philippine Islands. It is occasionally brought

[2] Peters, Monatsber. Akad. Wiss. Berlin (1868) 275.

alive to the Manila markets in considerable numbers, being caught in the bañgos fishponds of Bulacan and Pampanga.

According to Day it reaches a length of several feet. My specimens range in length from 191 to 415 millimeters. This is a fish of shallow seas, coastal waters, and estuaries, particularly where brackish, and it ascends rivers, mostly within or near the influence of the tides. It is known from India eastward to the Philippines, New Guinea, and Dampier Archipelago on the coast of West Australia.

Order APODES

EELS

This order includes bony fishes with the premaxillaries greatly reduced or absent, the maxillaries lateral, and the body eel-like, without ventral fins, and either naked or with vestigial or very small scales. The pectoral arch is not attached to the skull, and pectoral fins may be present or absent. The intermaxillaries are represented by a bony plate bearing teeth, which fills in the space anteriorly between the dentigerous maxillaries which form the upper jaw. When present the caudal fin is united with the dorsal and anal, the fins never being spinous. The vertebræ are numerous and not specially modified, those of the tail remaining in a straight line to its extremity—isocercal.

When very young the eels are translucent ribbon-shaped creatures of the oceanic abysses or the open sea. These larval forms were long known as Leptocephali, and pass through a series of changes before assuming the adult form. *Leptocephalus,* however, can no longer be used as a name for larval eels and isospondylous fishes, but under the rules of synonymy must be restricted to the conger eels.

Simplicity of structure in the eels is not an indication of primitiveness but is evidently the result of degeneration of the mouth parts and fins. The Apodes seem to be an offshoot from the soft-rayed fishes, and their divergence from them is, as a whole, a retrogression.

This is a large order, of great interest to the systematic zoölogist, the evolutionist, the geographer, the ecologist, the food economist, and the business man. Some representatives occur in all tropical and temperate regions, and in both fresh and salt water, but the species are mostly marine. They particularly abound about tropical reefs and often have very beautiful or

bizarre coloration. The species found in fresh waters and cool seas or in oceanic depths are always of plain and dark or silvery coloration. Many of the reef-dwelling eels strikingly resemble snakes and worms, in both external appearance and habits. They vary greatly in size from those like earthworms or intestinal round worms up to huge serpentlike forms more than 3 meters in length. Many genera and species have been described but, owing to our very limited knowledge of their breeding habits, larval development, and the changes due to sexual maturity and old age, many of the published species are merely nominal or include two or more species. It is my belief that further collecting will increase the number of valid species in the Philippines to seventy-five or eighty.

Key to the suborders and families of Apodes known from the Philippines.

a^1. Gill openings well developed, leading to large interbranchial slits; tongue present; opercles and branchial bones well developed; scapular arch present and free from the skull.................... Suborder **Enchelycephali.**

b^1. Skin covered with embedded linear or narrowly oblong scales; anterior nostrils on top of snout, posterior ones in front of eyes; pectorals well developed as are the vertical fins which are confluent with caudal; lower jaw projecting; tongue with its margins free; teeth in cardiform bands on jaws and vomer; eggs minute..... **Anguillidæ.**

b^2. Scales wholly wanting; eggs of moderate size, so far as known, much as in ordinary fishes; pectorals present or absent; nostrils marginal, lateral, or superior.

c^1. Tail not greatly shorter than rest of body; heart close behind gills.

d^1. Nostrils lateral or superior.

e^1. Tongue broad, free anteriorly and on sides; dorsal, anal, and caudal well developed and confluent; tail sometimes ending in a long filament; coloration nearly always plain, blackish, brownish, or silvery, fins often black margined; teeth moderate.

f^1. Pectorals vestigial or absent; snout obtuse, very short, the lower jaw projecting; cleft of mouth strongly oblique; body excessively elongated, depth 48 to 80 in length; needlelike teeth in bands.. **Heterocongridæ.**

f^2. Pectorals well developed; body moderately elongate, depth 14 to 26 in length; lower jaw more or less included; teeth in bands, those on sides forming a cutting edge. **Leptocephalidæ.**

e^2. Tongue narrow, not free; vomerine teeth usually well developed, often enlarged. Pectoral fins well developed; dorsal, anal, and caudal well developed and confluent; upper jaw prominent, its rounded tip separated by a notch from rest of snout; vomer with numerous large conspicuous canines. **Murænesocidæ.**

d^2. Anterior nostrils in a short tube at margin of upper lip; posterior nostrils usually in upper lip in a valve, flap, or slit just forward of or below eye and opening downward.

g^1. Caudal present and confluent with dorsal and anal; anus in anterior half of length .... **Myridæ.**

g^2. Caudal absent; tip of tail not threadlike and projecting beyond dorsal and anal when these are present; anus far back, before or behind middle of body .... **Ophichthyidæ.**

c^2. Tail much shorter than rest of body; heart far behind gills; nostrils superior; dorsal and anal confined to tail, confluent with caudal, and often reduced to a low fold .... **Moringuidæ.**

a^2. Gill openings small, more or less circular or horizontal slits, widely separated; tongue wanting or closely adnate; opercles feebly developed; fourth gill arch modified, strengthened, and supporting pharyngeal jaws; skull very narrow .... Suborder **Colocephali.**

b^2. Pectorals wanting; dorsal and anal more or less developed or vestigial, confluent with caudal, covered with thick skin; teeth in two, three, or more rows when dorsal and anal are vestigial or absent; often large and strikingly colored .... **Murænidæ.**

ANGUILLIDÆ

TRUE EELS

Local names; Bagobo, *casili;* Bicol, *casili, borirauan;* Bontoc Igorot, *tjalid;* Ibanag, *quiuo-t, siging;* Ilocano, *quioet, igat;* Ivatan, *tuna,* applied to all kinds of eels; Moro, *casili;* Pampangan, *talunasan, palus;* Sambali, *talunasan, talunajan;* Tagalog, *igat, pabucañgbinhi;* Tirurei, *berrirró;* Visayan, *casili, bais.*

This is the most primitive family of living eels and is composed of a single genus of plain dark-colored elongate fishes, characterized especially by having very small, more or less linear-oblong rudimentary scales, occurring in small groups and placed separately at right angles to the adjacent groups. They are found in fresh and brackish waters of the temperate and tropical regions except those of the western coast of North America, the west coast of Africa, and South America. The "electric eels" of the tropical fresh waters of the last-named continent are related to the catfishes.

Additional characters are as follows: Body elongate, subcylindrical, becoming laterally compressed behind; lateral line well developed; head long, conical, more or less pointed, the small eye well forward and over angle of mouth; teeth small, conical, mostly uniform in size, in rather wide bands on each jaw and a long patch on vomer; tongue free at tip, lips thick and full with a free margin behind, attached by a frenum in front, the lower jaw more or less projecting; gill openings rather small, slitlike, vertical, about as wide as base of the well-devel-

oped pectorals, lying below and just in front of these; nostrils superior, well separated, the anterior with a small tube; origin of dorsal some distance from head, vertical fins confluent with caudal; vent just before anal.

Perhaps fifty species of *Anguilla* have been described, most of them based upon individual differences due to age or sex, and it is probable that the number now recognized may be still further reduced. Until the fresh-water eels of the world are monographed by some one having before him a complete series of specimens in all stages of growth, we may safely admit as valid one European, one North American, one Japanese, and five or six Indo-Pacific species, eight or nine in all.

The Indo-Pacific species of *Anguilla* are the best defined of the genus and attain by far the largest size. These gigantic eels play an important part in the mythology of some of the Polynesians, as the Samoans and Maoris, and among the Malayans, as the people of Celebes and the hill people of Mindanao and northern Luzon. Among the Lepanto Igorots the eel cult is well developed. Near the town of Kágubátan at the foot of the sacred mountain Múgao, are several small lakes or ponds in which are many large sacred eels. The fish are fed every day with rice and sweet potatoes brought by children of the neighborhood, who sing a song which acts as a signal for the eels to come and be fed. In this song they ask the eels to take the food, to bestow good health upon the givers, and to protect them from sickness. The people say "our fathers had these eels" and "it would be death to the person injuring one," while the springs would dry up and there would be no water for the rice terraces. Another aspect of their relations to man is given in the charming little fairy tale "Talia" of northern Benguet, translated by Prof. Otto Scheerer.[3]

Superstitions concerning eels are widespread among the Christian Filipinos. They say the eel contains a magical stone, or *mutya,* which gives the possessor the power to escape from any knots or fastenings. This is evidently a form of the widespread belief in the bezoar stone, but in this case the slippery agility of the eel is transferred to the owner of the mutya. Such Filipino names as *talunasan* refer to the slipperiness of the eel. Some people also believe that if eels are eaten when one is recovering from an illness the disease will attack him again with the utmost severity, and death will be almost sure to follow.

[3] Philip. Journ. Education 2 (1920) 193–202.

Since some kinds of eels are oily and more indigestible than many other fishes, this belief is evidently founded on sound observations but faulty deductions. The convalescent dies of indigestion after a hearty meal of eel, not from a recurrence of the disease.

Eels are among the greediest and most active of fishes, though like many other fresh-water fishes they are much more active by night than by day. They not only devour anything living that is small enough for them to catch, but also delight to feed upon any kind of dead or even putrid carcass.

From time immemorial students have puzzled over the time and place where eels spawned. Every spring vast hordes of tiny young eels ascended the rivers, making their way over waterfalls, dams, and even crawling through damp grass to places not to be reached by swimming. Here, far from the sea, they reached a large size but no sexual development followed. In the fall large eels were observed going downstream, these being the ones caught in the eel pots that the fishermen set in the estuaries. All sorts of theories and speculations were advanced to account for the mystery, and it was not until 1707 that the female eel was first made known, while the male was not discovered until 1873. Many more years of patient investigation were required before the life history of the European and American eels was known, while that of the Indo-Pacific eels is still almost a total blank.

When the European eels attain proper maturity they make their way downstream to salt water. Continuing westward they ultimately reach the edge of the continental shelf and drop off into the depths, still westward bound. On arriving in salt water their gonads develop rapidly, and by the time they reach the western Atlantic they are ready to reproduce. In a region about 27° north and 60° west, southwest of Bermuda, and at a depth of about 500 fathoms, the eggs are laid and fertilized, the adults then perishing. Our knowledge of the location of the spawning grounds is due to the investigations of Dr. Johannes Schmidt, of Copenhagen. The American eel has its spawning places in a zone west and south of the European, but overlapping. The larvæ of both species appear to pass their earliest stages together, but when they are about 3 centimeters long one species turns toward Europe, the other toward North America.

When hatched the larvæ, in common with those of some other eels and most isospondylous fishes, are delicate, ribbon-shaped creatures of glasslike transparency and with disproportionately small heads. In this stage they are known as Leptocephali, many having been originally described under this name before their true relationship was recognized.

Making their way to the surface, they drift toward the coast of Europe or America, as the case may be, reaching the former at the end of the second year, the latter at the end of the first. Through the compacting of their tissues they become shorter, lose their ribbon shape, and become eel-like, the European species entering the mouths of rivers as small, unpigmented eels about three years after their parents entered the sea. Here they darken to the characteristic color and begin ascending the rivers, the females going up to the headwaters, sometimes 3,200 kilometers or more from the sea. The males, so far as known, do not go beyond the brackish reaches of river mouths, and mostly remain in salt-water lagoons and bays along the coast.

The young eels sometimes ascend streams near the sea in incredible numbers, so that it is impossible to dip a bucket of water without taking a large number. All ordinary obstacles are easily passed, and they reach lakes having an elevation of 915 meters above the sea. Spencer F. Baird found hundreds of wagonloads of young eels crawling over the rocks and squirming in the whirlpools at the foot of Niagara Falls, which of course they could not surmount.

From specimens collected by the Siboga Expedition under the direction of Dr. Max Weber, we may be certain that the Indo-Pacific species of *Anguilla* have a similar life history, as many Leptocephali in different stages of development were obtained, some of which Weber believes to belong to *Anguilla*. One of these, having a length of 115 millimeters, was collected in the Sulu Sea at a depth of 1,270 meters. So far as I am aware, there are no data upon the breeding grounds of the *Anguillas* of Japan and the adjacent Asiatic coasts, or any of the Indo-Pacific species.

Four species of *Anguilla* are certainly known to occur in the Philippines, though their distribution is not determined, owing to lack of material. At least two species occur in the same localities, and it is probable that all of them will be found to occupy overlapping territory.

Genus **ANGUILLA** Shaw

Anguilla SHAW, Gen. Zool. 4 (1804) 15.

Characters of the genus included above.

Key to the Philippine species of Anguilla.

a^1. Origin of dorsal much in advance of anus.
  b^1. A toothless groove divides the bands of teeth lengthwise in both upper and lower jaws .... **A. mauritiana.**
  b^2. Bands of teeth in both jaws without a toothless groove. **A. celebesensis.**
a^2. Origin of dorsal not far in advance of anus.
  c^1. Origin of dorsal above or slightly before anus; gape extending to hind border of eye or beyond .... **A. australis.**
  c^2. Origin of dorsal above or behind anus; gape not reaching rear margin of eye .... **A. spengeli.**

Anguilla mauritiana Bennett.

Anguilla mauritiana BENNETT, Proc. Comm. Zool. Soc. London (1831) 128; EVERMANN and SEALE, Bull. U. S. Bur. Fisheries 26 (1906) (1907) 56; JORDAN and RICHARDSON, Bull. U. S. Bur. Fisheries 27 (1907) (1908) 237; SEALE and BEAN, Proc. U. S. Nat. Mus. 33 (1907) 239; WEBER and BEAUFORT, Fishes Indo-Austr. Arch. 3 (1916) 245, figs. 100 and 102.

Muræna maculata BLEEKER, Atlas Ichth. Muræn. 4 (1864) 9, pl. 1, fig. 2.

? *Muræna manillensis* (?) BLEEKER, Atlas Ichth. Muræn. 4 (1864) 10, pl. 44, fig. 2.

Depth 12 to more than 17 in length (14 to 21 according to Weber and Beaufort), head 6 to 7.3 (7 to 7.75, Weber and Beaufort), and 1.6 to 2 in trunk; eyes rather small, 8.6 to 14 in head, 1.7 to 3 in interorbital space, and $1\frac{2}{3}$ to 3 in the broad, blunt snout, the latter 4 to 5.4 in head; breadth of snout at its base usually greater than its length; the large mouth reaches beyond posterior margin of eye (in one specimen to the posterior border) and is 2.6 to 3.25 in head; lips noticeably thick and fleshy; length of head usually more than or may be equal to distance from gill openings to origin of dorsal, which is always well forward; distance from origin of dorsal to anus equal to or greater than distance from head to dorsal origin, and in small specimens it may be nearly twice as much; pectorals with sixteen to eighteen rays and 2.3 to 3.4 in head; tail exceeds length of head and trunk together by a distance varying from one-half the length of head to one and one-third times head in small specimens.

Maxillary teeth form a broad band, longitudinally divided by a toothless groove; intermaxillary and vomerine teeth form

a broad band separated from those of maxillaries on either side by a concave toothless groove; posteriorly they taper rapidly and do not extend as far back as maxillary teeth; teeth of mandibles separated at symphysis by a groove, and each band is likewise divided lengthwise by a rather wide toothless groove; the series of teeth in both upper and lower jaws much reduced posteriorly, the series inside groove tapering into a single row.

The color in life varies considerably, ranging from olive green mottled with dark brown to clay yellow variegated with darker; the commonest color is probably gray-brown marbled and clouded with dark brown, olive, or blackish; the belly and throat paler brown, yellow, or even white. The color in alcohol is similar but paler, while the marblings may be less evident.

This species is common in the Philippines, specimens being recorded from Calayan, north of Luzon, to Jolo. In northern Luzon they occur in mountain streams up to an altitude of more than 1,530 meters. The profile and proportions change greatly with age, old specimens probably being the bulkiest and largest of all eels, though exceeded in length by *Evenchelys macrurus*, and perhaps by *Murænesox talabon*. In the Manila markets one may see living specimens from Laguna de Bay up to a length of 2 meters and a circumference of about 460 millimeters.

I have examined specimens from Pinacañauan River, Cagayan Province, Ilocos Sur, Bontoc, Mountain Province, the mountains of Zambales near Iba, Laguna de Bay, and Bicol River, Luzon; from Cabalian in Leyte; from the Pulangi, Mindanao; and from Sibuyan, Masbate, Polillo, and Jolo Islands. Jordan and Richardson listed it from Calayan and Mindoro, Evermann and Seale from Tarlac, Seale and Bean from Zamboanga, Bleeker from Manila, and Günther from the "Philippines." My smallest specimen is 190 millimeters long.

This eel is in great favor among the Tagalogs, and commands very high prices, 8, 10, or even 15 pesos sometimes being paid for a single fish. It is known from Natal and the east coast of Africa, the islands of the Indian Ocean and the East Indies, north to Formosa, southeast to South Australia, and throughout the South Pacific to the Society Islands.

Anguilla manillensis Bleeker is said to have the mouth reaching hardly beyond the middle of the eye and to show some less-important differences, but I have not seen it and doubt its specific identity. In all the numerous specimens thus far examined by me the mouth has reached beyond the eye except in the small specimens (190 millimeters long) from Jolo, where it came only to the posterior margin of the eye.

Anguilla celebesensis Kaup.

Anguilla celebesensis KAUP, Cat. Apod. Fishes Brit. Mus. (1856) 42, fig. 31; WEBER and BEAUFORT, Fishes Indo-Austr. Arch. 3 (1916) 247, figs. 99 and 101.

Anguilla megastoma KAUP, Cat. Apod. Fishes Brit. Mus. (1856) 50, fig. 42; JORDAN and SEALE, Bull. U. S. Bur. Fisheries 25 (1905) (1906) 192.

Anguilla amboinensis PETERS, Monatsber. Akad. Wiss. Berlin (1866) 523.

Anguilla aneitensis GÜNTHER, Cat. Fishes Brit. Mus. 8 (1870) 34, Fische d. Südsee 3 (1910) 391.

Depth 14 in length, 1.83 in head; the latter 7.68 in length and 2.1 in trunk; head and trunk together equal to two-thirds length of tail, the trunk alone 2.28 in tail; eye, interorbital space, and breadth of base of snout equal; snout 4.78 in head, gape 2.75, pectoral fin 2.6. Mouth extends an eye diameter beyond eye. Distance from head to origin of dorsal 1.38 times the length of head; from origin of dorsal to anus eight-elevenths of head.

Teeth very numerous, pointed, uniform in size, depressible, directed backward; intermaxillary and vomerine teeth form a band which is slightly wider at first than the maxillary bands and tapers very gradually backward until it is about two-thirds as wide; maxillary bands separated from vomerine band by toothless grooves; they taper very slightly and extend as far back as the vomerine band does; bands in mandible separated by a toothless groove at apex of jaws.

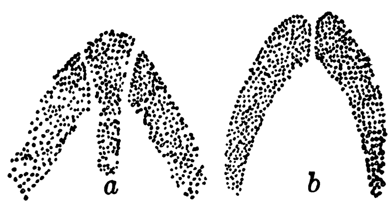

FIG. 1. *Anguilla celebesensis* Kaup, dentition; *a*, vomer and maxillaries; *b*, mandibles. After Weber and Beaufort.

Body stout, head flat and depressed, lips very thick, reflexed, with large pores on lips and snout; distance between origin of dorsal and origin of anal almost equal to head.

Color in alcohol blackish to grayish above, the sides more or less mottled with yellowish, becoming pale yellow on chin, throat, and belly; underside of tail and anal fin likewise mottled; anal and dorsal fins with pale or yellowish margins. In living specimens pectoral dusky, pale margined, the yellow much more noticeable, and the general color paler.

Here described from a specimen from Lake Lanao, having the following dimensions: Length, 845 millimeters; depth, 60; head, 110; trunk, 232; tail, 512; eye, 9; snout, 23; gape, 40; pectoral,

42; interorbital space, 23. I have also examined a second specimen from Lake Lanao, having a length of 795 millimeters.

This species is common in Lake Lanao and has been recorded by Casto de Elera from Manila. Lake Lanao is a large fresh-water lake in northern Mindanao, having an area of 176 square kilometers, and lies at an elevation of slightly more than 670 meters. It is very deep along the southern shore, the military finding a depth of over 150 fathoms near Bayong when laying the cable which crosses the lake. The only outlet is through the Agus, a small river at the northern end of the lake, only about 30 kilometers in length, and over a large part of its course a continuous rapid. Near the coast it takes a leap of 58 meters, the Maria Cristina Falls. As fresh-water eels spawn only in the ocean, this presents a very interesting problem. It is evidently impossible for any fish either to ascend or to descend these falls directly, but a recent visit to Lanao offers a reasonable explanation of the puzzle.

Eels occur in such isolated lakes as Nunuñgan, which is entirely surrounded by mountains but which has a subterranean outlet. Through this channel eels and small Cyprinidæ come and go. The whole volcanic plateau of Lanao has many such subterranean water courses.

An inspection of Maria Cristina Falls shows that the lower gorge of the Agus terminates in a box cañon, the falls being caused by the river leaping from the upper valley over the precipice. On the south side of the gorge, perhaps a third of the way above the torrent at the bottom, is a layer of rock which is evidently honeycombed with water passages. From this layer issue many small cascades and spurting streams which tumble down the talus blocks into the boiling river below. Owing to the overhanging nature of the cliffs on the north side, where only one can safely view the falls, it is impossible for me to say whether there is a similar layer of cavernous water-bearing rock on that side or not. There can be no doubt that very slender young eels crawl up the wet talus, enter the crevices in the water-carrying layer of rock, and work their way up against the subterranean streamlets until they reach the river well above the falls.

The relative proportions of length, depth, head, eyes, interorbital space, snout, and mouth vary considerably with age and stoutness, large specimens being relatively more robust, with smaller eyes and larger mouth. According to Weber and Beau-

fort the eyes vary from 6.6 (in young) to 13.5 in the head, 1.3 to 2.3 in the interorbital space, and 1.1 to 2.5 in the snout; the gape 2.4 to 4 in the head. There is also considerable variation in the number of teeth, the length and shape of the vomerine band, and the degree to which the dental bands taper. The location of the origin of the dorsal likewise varies, but it is always nearer the anus than the gill opening and the distance between the origin of the dorsal and of the anal is about equal to the length of the head or a very little more or less.

The synonymy cited above does not include all grouped under *Anguilla celebesensis* by Weber and Beaufort, inasmuch as the original descriptions are often incomplete, contradictory, and confusing, and while their arrangement may be correct the type material should be examined in order to settle the matter. My specimen is much more robust and has a flatter profile than the figure given by Weber and Beaufort, but it agrees almost exactly in dentition with their figure 101.

This species is abundant in Borneo, Celebes, New Guinea, and the smaller islands grouped about them, and in the South Sea Islands, where it reaches a gigantic size. It is a food fish of considerable importance wherever found.

Anguilla australis Richardson.

Anguilla australis RICHARDSON, Proc. Zool. Soc. London (1841) 22.
Muræna sidat BLEEKER, Atlas Ichth. Muræn. 4 (1864) 10, pl. 3, fig. 3.
Muræna moa BLEEKER, Atlas Ichth. Muræn. 4 (1864) 11, pl. 4, fig. 1.
Muræna australis BLEEKER, Atlas Ichth. Muræn. 4 (1864) 12, pl. 7, fig. 1.
Muræna halmaherensis BLEEKER, Atlas Ichth. Muræn. 4 (1864) 12, pl. 6, fig. 4.
Anguilla bicolor and *virescens* GÜNTHER, Cat. Fishes Brit. Mus. 8 (1870) 35.
Anguilla sidat and *australis* GÜNTHER, Cat. Fishes Brit. Mus. 8 (1870) 36; JORDAN and SEALE, Bull. U. S. Bur. Fisheries 25 (1905) (1906) 192.
Anguilla bicolor DAY, Fishes of India (1878–88) 660, pl. 148, fig. 2.

Depth 13.6 to 17 in length, head 7.2 to 8.5 and 2 to 2.25 in trunk; eye small, 11 to 11.7 in head in my specimens (8 to 10 according to Weber and Beaufort), 2 in snout (1.2 to 2.1, Weber and Beaufort), and 2.25 in interorbital space (1.5 to 2.8, Weber and Beaufort); snout a sixth or seventh wider at its base than its length, which is 5.5 in head (6 to 8, Weber and Beaufort); mouth reaches beyond eye, its gape from 3.28 to 4 in length of head; pectorals with fourteen rays, 3.4 in head ($2\frac{2}{3}$ to 3.5, Weber and Beaufort); tail exceeds head and trunk

together by 1.28 to 1.37 times the length of head, or 28.3 to 31.5 per cent of its own length; dorsal begins exactly over anus in my specimens, though usually it is inserted a little before vent and anal begins a very short distance behind it.

Upper jaw has a continuous many-rowed band of small teeth, which tapers posteriorly and unites anteriorly with the vomerine teeth without a delimiting groove at junction; teeth on vomer in an elongate paddle- or pear-shaped band which extends as far back as do the maxillary bands; bands of teeth in lower jaw broadest anteriorly, tapering posteriorly; they are almost separated at the symphysis by a distinct groove, being united and continuous only at the extreme anterior portion.

Specimens in alcohol uniform dark brown above, merging into very pale brown beneath; anal pale or light yellowish except near tip of tail where it is dark; in life all the fins were evidently uniform in coloration with back and sides.

Here described from two specimens, 515 and 600 millimeters in length, collected by Mr. Alejo Arce at Lake Bato, Camarines. There are two stuffed specimens, collected at Cavite, in the museum of the University of Santo Tomas. There is also a specimen, 320 millimeters long, from Guam in the Bureau of Science collection. This specimen has the eye contained but 7⅝ times in the head, and is quite different in several respects though it undoubtedly belongs here. The undersurface and all except the posterior fifth of the anal are clear uniform pale yellowish.

This eel reaches a length of 1 meter and occurs from Natal and the east coast of Africa to the coasts of India, the East Indies, Tasmania, New Zealand, and the islands of the South Pacific.

Anguilla spengeli M. Weber. Plate 1, fig. 1.

Anguilla malgumora SCHLEGEL, Mus. Lugd. Bat., nec Kaup.

Anguilla mowa BLEEKER, Verh. Bat. Gen. 25 (1853) Muræn. 16, pro parte.

Muræna malgumora BLEEKER, Atlas Ichth. Muræn. 4 (1864) 11, pl. 2, fig. 1, nec Kaup.

Anguilla malgumora KNER, Novara Exp. 1 Fische (1865–67) 367.

Anguilla spengeli MAX WEBER, Zool. Jahrb. Suppl. 15, 1 (1912) 591; WEBER and BEAUFORT, Fishes Indo-Austr. Arch. 3 (1916) 249.

Depth 12.87 in length, head 7, and 2 in trunk; tail exceeds rest of animal by a little less than the length of head (96.5 per cent) or 24.2 per cent of its own length; jaws equal, lips comparatively thin; eye moderately large, 9.7 in head, 2 in the broad,

triangular, rather sharp snout, and 2⅓ in the interorbital space; mouth of medium size, its gape 3.6 in head; as is often the case in eels the mouth is asymmetrical, on one side not extending beyond the pupil, on the other not reaching the rear margin of the eye; pectorals two-thirds as broad as their length, which is 2.75 in head; origin of dorsal behind anus and farther back than origin of anal; teeth of nearly uniform size, those of upper jaw forming a broad continuous band which tapers but little posteriorly; it is continuous around anterior outer portion of intermaxillary plate and partially separated by two distinct lateral grooves on inner anterior side from the broad vomerine band, which tapers but little posteriorly and does not extend backward as far as do the maxillary teeth; bands in lower jaw partially separated by a groove which does not reach to anterior margin so that they are continuous there; posteriorly they taper gradually to about half their greatest anterior breadth.

Color in life uniform very dark olive brown, slightly paler to yellowish on belly; pectorals, dorsal, and caudal blackish; color in alcohol similar but paler, becoming brown laterally to yellowish under head and belly; anal with a pale margin except near caudal.

Here described from a specimen obtained by me in Cotabato River, Mindanao, not far from its mouth. In the position of the dorsal it resembles *Anguilla dussumieri* Kaup, but does not agree with it otherwise as far as can be judged from Kaup's figure and unsatisfactory description. This specimen differs also from any other I have examined in the greater development of its caudal fin and the contiguous confluent portions of the dorsal and anal. Length, 615 millimeters; head, 88; trunk, 177; tail, 350; depth, 40; eye, 9; snout, 18; gape, 24; origin of dorsal, behind anus, 15.

A rare East Indian species, also recorded by Kner from Australia. According to Bleeker the eye is contained from 6 to 6.5 times in the head; the difference in my specimens may be due to their much larger size since as a rule the eyes are proportionately larger in young specimens.

LEPTOCEPHALIDÆ

This family includes scaleless eels having the tongue largely free in front, the body elongate, with lateral line and well-developed pectoral and vertical fins, the latter confluent around the tail; the posterior nostrils distant from the upper lip and near the front of the eye; the lower jaw more or less included.

These eels are found at moderate depths in most warm and temperate seas and estuaries, and also enter brackish and fresh water. All the species are plainly colored, grayish, dusky, or brownish above and pale or silvery beneath.

Like the Anguillidæ and some isospondylous fishes, the conger eels undergo metamorphosis. When hatched they are strange-looking, elongate, transparent, ribbonlike animals with minute head and very tiny mouth. With advancing age the body becomes smaller as the tissues are compacted until after a year or so they assume the general form of the adult.

Key to the genera of Leptocephalidæ.

a^1. Anterior nostrils in a tube.
  b^1. Origin of dorsal over or behind middle of pectorals.... **Leptocephalus.**
  b^2. Origin of dorsal above, before, or slightly behind base of pectorals. **Ariosoma.**
a^2. Anterior nostrils not tubulate. Dorsal beginning over or behind base of pectorals; tail strongly tapering, very long, and whiplike. **Uroconger.**

Genus LEPTOCEPHALUS Scopoli

Leptocephalus SCOPOLI, Int. Hist. Nat. (1777) 453.

CONGER EELS

Large and powerful marine eels, which strongly resemble *Anguilla* in general appearance but lack scales, the elongate body becoming much compressed posteriorly. Vertical fins well developed, confluent with caudal, origin of dorsal above the well-developed pectorals. Head of moderate size, depressed, often flat above eyes, pointed; eye large, covered by skin; posterior nostrils opposite upper or middle part of eye, anterior nostrils in short tubes near tip of projecting snout; mouth extending to middle of eye or beyond, lips thick and large; tongue free. Teeth small, those in outer series in both jaws equal, compressed, and close-set, forming a cutting edge; the inner series incomplete or partially developed or even absent, of small conical teeth; teeth on vomer arranged in a short conical band, the point of which is directed backward; no canines. Lateral line present. Gill openings large, extending from pectorals downward. The skeleton differs much from that of *Anguilla*; vertebræ about 56 + 100.

This genus includes the well-known and almost cosmopolitan conger eel and a few closely related species. Some representative of the genus is found in nearly all temperate and tropical seas. I have been unable to learn of any distinctive names

applied to the species of this group by any of the Filipinos with the exception of the Visayans, who call them *obud* or *obod*.

I have described one species of wide distribution in the Indian and Pacific Oceans, and one larval form known only from the Philippines.

Leptocephalus cinereus (Rüppell).

Conger cinereus RÜPPELL, Atlas Reise Nördl. Afrika, Fische des Rothen Meers (1828) 115, pl. 29, fig. 1; WEBER and BEAUFORT, Fishes Indo-Austr. Arch. 3 (1916) 258, figs. 5, 107, and 108.

Conger marginatus VALENCIENNES in Eydoux and Souleyet, Voyage Bonite, Poiss. (1841) 201, pl. 9, fig. 1.

Leptocephalus marginatus JORDAN and EVERMANN, Bull. U. S. Fish Comm. 23 (1903) (1905) 76.

Conger noordzieki BLEEKER, Atlas Ichth. Muræn. 4 (1864) 26, pl. 23, fig. 2.

Head and trunk 2 in tail; head 8.68 in total length and 1.88 in trunk; greatest depth 16.44 in total length; mouth 2.4, snout 3.6 in head; eye longer than high, its length a trifle more than one-third that of jaw and equal to interorbital space; pectoral 2.88 in head.

Body elongate, rounded, becoming strongly compressed and tapering on tail; head long, pointed anteriorly but sides bulging strongly just behind eye; snout depressed, flattened above, and projecting beyond lower jaw; eye large, elliptical; mouth moderate, reaching not quite as far as hinder margin of eye, lips broad, thick, fleshy flaps; anterior nostrils near tip of snout, in short tubes which point downward; posterior nostrils immediately in front of eye and slightly below its upper margin; pectoral at upper angle of large gill openings; origin of dorsal just behind middle of pectoral.

Color dark grayish brown above, the undersurface pale to whitish, much paler anteriorly; a blackish streak from forward margin of eye to behind angle of mouth; dorsal and anal pale, becoming dark far back on tail, their free margin with a black band, edged with white; pectorals with a conspicuous black blotch.

The description above is from a specimen 625 millimeters long, purchased in the market at Jolo. Its other measurements are as follows: Head, 72 millimeters; tail, 417; depth, 38; upper jaw, 30; snout, 20; eye and interorbital space, each 11.

An unlabeled specimen in the Bureau of Science collection has the following dimensions: Length, 610 millimeters; head,

78; tail, 390; depth, 34. I have also collected two specimens at Dumaguete, Oriental Negros, with lengths of 550 and 320 millimeters, respectively.

Authors state that the depth of this eel is contained from 16 to 20 times in the total length, and the head from 8 to 9 times; the tail is usually less than twice the length of head and trunk.

According to Günther this eel reaches a length of 1.25 to 1.6 meters. It occurs throughout the Indo-Pacific region from the Red Sea, Madagascar, and the east coast of Africa to the Hawaiian and Samoan Islands. It is esteemed as food in the Sulu Archipelago.

It is with some doubt that I follow Weber and Beaufort in adopting Rüppell's name in preference to *Conger marginatus* of Valenciennes. Rüppell's description might apply but his figure is far from convincing and resembles but little the specimens I have seen from Hawaii, Samoa, and the Philippines.

Leptocephalus brevicaudus Peters.

Leptocephalus (*Diaphanichthys*) *brevicaudus* PETERS, Monatsber. Akad. Wiss. Berlin (1864) (1865) 399.

Körper ganz platt zusammengedrückt, die Profillinie der Bauchseite convex, die des Rückens fast gerade. Schnauze sehr spitz, vor dem Auge convex, ein wenig kürzer als der Augendurchmesser; Maul bis unter die Mitte des Auges gespalten, jederseits oben und unten mit 8 geraden spitzen, und hinten im Oberkiefer mit noch einigen kleineren spitzen Zähnen bewaffnet. Die hinteren Nasenlöcher liegen auf der Schnauze, den Augen etwas näher als der Schnauzenspitze. Die Augen liegen in der Mitte des Kopfes. Kiemenspalten sehr eng. Keine Brustflossen, keine Rücken- und Afterflosse, indem das Körperende nur von der Schwanzflosse umfasst wird, welche sich oben und unten auf 1.5 Millimeter ausdehnt. Die untere Körperhälfte ist in der Körpermitte reichlich 1/3 höher als die obere Hälfte. Der farblose Körper zeigt längs der Rückenfirste sowie jederseits neben dem Darmcanal eine Reihe schwarzer Pünktchen und unter der Chorda, dem Anfange der ventralen Muskelabtheilungen entsprechend, feine schiefe Linien von derselben Farbe.

Totallänge 88 mm.; Kopf 35 mm.; von der Schnauzenspitze bis zum hinteren Augenrande, 2 mm.; vom After bis Schwanzende (ohne Flosse), 33 mm.; Höhe der Körpermitte, 13 mm.

This larval eel is known only from eight examples caught by Doctor Jagor in the open sea between Masbate and Luzon. The smallest specimens had a length of but 60 millimeters, but all had the same structure and proportions.

In the present state of our knowledge we cannot identify these larvæ with any known adult species.

Genus **ARIOSOMA** Swainson

Ariosoma SWAINSON, The Natural History of Fishes, Amphibians, and Reptiles or Monocardian Animals 2 (1839) 194.
Congrellus OGILBY, Proc. Linn. Soc. New South Wales (1898).

A genus comprising many small congers distinguished by the more forward origin of the dorsal and the greater development of large mucus cavities in the front part of the head; snout usually prominent; posterior nostrils opposite middle of eye, the anterior ones near tip of snout and tubulate; mouth wide, not reaching hinder margin of eye; teeth acute, in bands or in a few series in jaws, not forming a cutting edge; vomer with a short patch of larger teeth or a patch of small teeth tapering into a rather long and gradually larger series; teeth on intermaxillary plate small or forming a patch of larger teeth forward of mouth; gill openings wide apart, nearly vertical, beginning below upper margin of base of pectorals, much narrower than their interspace or the diameter of eye.

Ariosoma Swainson must take precedence over *Congrellus* Ogilby.

Ariosoma obud[4] sp. nov. Plate 1, fig. 2.

Depth 3.1 in head, 18.4 in length; head 5.9 in length, 1.55 in trunk; head and trunk together about $2\frac{1}{3}$ in total length and three-fourths as long as tail; eye 4.42 in head, and almost as long as snout; gape extends to a point beneath forward margin of eye and is $3\frac{7}{8}$ in head; pectorals 2.8 in head.

Teeth very small and needlelike, the maxillary bands of about four rows at forward end, narrowing down at rear to two rows; a dense mass of slightly larger teeth covers intermaxillary plate, filling in all space between the forward ends of maxillaries, and merges into those of vomer which begin as three poorly defined rows and soon become a single series, five-sevenths as long as maxillary bands; teeth of the mandibles in four rows at forward end, becoming a single row posteriorly.

An elongate little eel with subcylindrical body and compressed tail; dorsal profile convex, snout projecting slightly, lower jaws weak; eye large, circular; lips thick and recurved; muciferous cavities and pores numerous and prominent on jaws and around eyes; those of lower jaw continuous with lateral line, which originates on nape; forty pores in lateral line forward of anus;

[4] From *obud*, a Visayan name for eels belonging to the Leptocephalidæ.

origin of dorsal over base of pectoral, highest near origin, where it is equal to one-half the depth of body, becoming lower posteriorly; gill openings much narrower than their interspace.

Color pale brownish gray, dorsal surface much darker than the part below lateral line; interspace between eyes blackish; body almost everywhere thinly sprinkled with minute dark dots, which extend to the hyaline fins, where they form indications of a black margin.

The above description is from a specimen obtained at Marinduque Island, with dimensions as follows: Length, 184 millimeters; head, 31; trunk, 48; tail, 105; depth, 10; eye, 7; snout, 7.5; gape, 8; pectoral, 11.

This is very close to *Congrellus anago* as described by Weber and Beaufort[5] but differs in several particulars, especially in the dentition, as may be seen by comparing the figure given with those just cited. Beyond question other species of the genus occur here, but as yet they have not been collected.

Genus UROCONGER Kaup

Uroconger KAUP, Cat. Apod. Fishes Brit. Mus. (1856) 110; WEBER and BEAUFORT, Fishes Indo-Austr. Arch. 3 (1916) 264.

Small elongated eels with a subcylindrical body and a very long and tapering whiplike tail which becomes strongly compressed laterally and is at least twice as long as trunk; pectorals well developed; dorsal beginning approximately over base of pectorals and confluent with caudal and anal; head conical, as deep as or deeper than body, the forward portion depressed, and the blunt snout projecting beyond lower jaw; eye moderately large, covered by skin; anterior nostrils near apex of snout, without tubules; posterior nostrils large slits near to and in front of eyes; mouth of medium size, extending a little beyond middle of eye; lips of moderate size, upper with a row of short slitlike mucus pores; tongue free; teeth needlelike, small but quite unequal in size, those of upper jaw in two rows, in lower jaw in two complete rows with a third very short inner row; teeth on vomer small, in one or two rows, sometimes with a few larger caninelike teeth in front; those on intermaxillary plate in two irregular series, eight or ten in number; some of them, especially the outer ones, may be enlarged; lateral line present; gill openings large, situated vertically before and below base of pectorals.

[5] Fishes Indo-Austr. Arch. 3 (1916) 262, figs. 109 and 111.

One East Indian species of shallow waters from Arabia to China, and two deep-sea forms from the Atlantic, Pacific, and Indian Oceans.

Jordan states in his recent work on the genera of fishes that this name is of doubtful validity.

Uroconger lepturus (Richardson). Plate 1, fig. 3.

Congrus lepturus RICHARDSON, Zool. Voyage Sulphur (1844–45) 106, pl. 56, figs. 1–6; Voyage Erebus and Terror, Fishes (1844) 109.

Uroconger lepturus KAUP, Cat. Apod. Fishes Brit. Mus. (1856) 110; BLEEKER, Atlas Ichth. Muræn. 4 (1864) 29, pl. 5, fig. 1; DAY, Fishes of India (1878–1888) 661, pl. 170, fig. 1; JORDAN and SEALE, Bull. U. S. Bur. Fisheries 26 (1906) (1907) 6; WEBER and BEAUFORT, Fishes Indo-Austr. Arch. 3 (1916) 265, figs. 113, 114.

Depth 20 to about 26 in total length; head 7 to 9 in length and 1.5 to 1.68 in trunk; head and trunk together 2 1/7 in tail, trunk alone 3.4; eye 5.5 to more than 7 in head, snout 3.8 to 4; mouth extends about to a perpendicular from rear margin of pupil of eye, 2.7 in head; pectorals 3.5 to about 4 in head.

A small blunt-headed eel with subcylindrical trunk and exceedingly elongate, slender, and laterally compressed tail which tapers to a point; the broad rounded snout projects slightly beyond lower jaw; dorsal begins above base of pectorals, its height equal to or a little more than half the depth of body; intermaxillary teeth in two transverse rows of four each, behind which are two pairs of smaller teeth and a single row of very small teeth on vomer which may become double posteriorly; lateral line prominent, beginning on nape.

Color uniform brown, thickly dotted with minute dark specks except on sides and underpart of head where it is very pale; vertical fins profusely dotted with dark specks and edged with black.

The only specimen in the Bureau of Science collection was obtained in the Manila market in 1907. It has lost about 5 millimeters from the tip of the tail. Its present dimensions are as follows: Length, 210 millimeters; head, 25; trunk, 42; tail, 143; depth, 8+; eye, 3.5; snout, 6.5; gape, 9; pectoral, 7.

There is a fine specimen 360 millimeters long from Mindoro in the museum of the University of Santo Tomas, and a specimen 12.5 inches long was noted from Manila by Jordan and Seale.

This very distinct little eel is of no economic importance apparently, being neither abundant nor large enough to rank as a food fish. It was originally described from the coast of

China and is found in shallow waters south and westward from Hongkong and Manila to the Sea of Oman, on the coast of Arabia.

As this paper goes to press I am in receipt of a specimen, 192 millimeters long, obtained at Luboc Beach, Lapaz, Iloilo Province, by Mr. Angel Villanueva, of the College of Agriculture, Los Baños.

MURÆNESOCIDÆ

Scaleless eels, often large and robust, the narrow tongue fastened to the floor of the mouth or only its tip free, the jaws elongate with strong teeth, the middle row on the vomer composed of large canines; gill openings rather wide; posterior nostrils not labial; pectoral, dorsal, and anal fins well developed, the last two confluent with the caudal.

Separated by Gill and given family rank on the basis of the skeletal differences. A small family, resembling the Leptocephalidæ in habits and appearance. Most of the genera are American.

Genus **MURÆNESOX** McClelland

Muræsenox McCLELLAND, Calcutta Journ. Nat. Hist. 4 (1843) 408.

The robust elongate body is subcylindrical, becoming compressed posteriorly; origin of dorsal above or slightly in advance of gill openings; head elongate, mouth large and extending well beyond eyes, with prominent, conical upper jaw, tip elongated, rounded, somewhat enlarged, and separated by a notch from rest of snout; anterior nostrils behind notch of snout and with a short tube; posterior nostrils in front of middle of eye, but at some distance from it; tongue adnate; maxillary teeth conical, in several rows, partly separated by a toothless interspace; teeth of mandible conical, in several rows, the outer of which may point outward, and the anterior teeth enlarged canines; vomer with several long series of teeth, the middle one of strong conical or compressed canines; gill openings rather wide, beginning opposite upper margin of base of pectorals, and separated from each other by a narrow interspace; lateral line conspicuous; anal opening in anterior half of body.

Large congerlike eels, important as food; found in all warm seas and notable for the large, strong teeth on vomer. We have two of the three East Indian species. The Filipinos do not distinguish these eels very clearly, the Tagalogs sometimes calling them *palos* or *pindangá*, the Visayans *obud*, *ubod*, or *palos*,

while the Sambali seem to have but the one word, *taleric,* which they apply to eels of the most diverse appearance.

Key to the species of Muræenesox.

a[1]. Median canines with distinct basal lobes both front and back; outer row of teeth in mandibles erect.......... M. cinereus.

a[2]. Median canines with never more than an indication of basal lobes; at least part of outer row of mandibulary teeth pointed outward. M. talabon.

Muræenesox cinereus (Forskål). Plate 10, fig. 1.

Muræna cinerea FORSKÅL, Descript. Anim. (1775) pp. X, 22.

Muræenesox cinereus GÜNTHER, Cat. Fishes Brit. Mus. 8 (1870) 46; WEBER and BEAUFORT, Fishes Indo-Austr. Arch. 3 (1916) 253, fig. 254.

Muræenesox bagio KAUP, Cat. Apod. Fishes Brit. Mus. (1856) 116, pl. 14, fig. 73; BLEEKER, Atlas Ichth. Muræn. 4 (1864) 24, pl. 26, fig. 2.

Muræenesox singapurensis BLEEKER, Atlas Ichth. Muræn. 4 (1864) 25, pl. 7, fig. 2.

Depth 17 to 22 in total length (in our specimens about 19.5 and 21.5), the strongly compressed head 6 to 7; the large elongate eye 8 to 10 in head and 2 to 4 in snout; mouth very large, about 2⅛ times in head; teeth in upper jaw in three rows, those in outer row very small, second row much larger, and inner row curved and separated by a toothless area from the other two; intermaxillary plate with five large canines (eight or ten, Weber and Beaufort), followed by a row extending down vomer composed of compressed canine teeth with a basal lobe in front and behind, the posterior teeth very large; a row of much smaller teeth on each side of median row; in some specimens they are so small as to be barely visible; in lower jaw an outer row of small, erect teeth, a middle row of large, compressed teeth, and posteriorly a partial or irregular row of small teeth; the middle row of each side ends anteriorly in one or two large canines, around which the outer row is continued by five to seven large teeth; origin of dorsal in advance of base of pectoral or even before gill opening; pectorals dusky to blackish, pointed, and contained from 2.2 to 3 times in head; height of dorsal about 1.5 in body depth; silvery or ashy gray, sometimes with a slight tinge of golden yellow along sides; vertical fins pale or yellowish, with broad black or brownish black margins and black caudal.

Here described from two specimens from the Manila market, measuring 400 and 433 millimeters in length. The Bureau of

Science collection also has six specimens from Alaminos, Pangasinan; one from Agno River, Pangasinan; one from Bancal River near Iba, Zambales; one from Calabang, Camarines; one from Tacloban, Leyte; two from Hongkong; and two from Sandakan, Borneo. These range in length from 265 to 650 millimeters.

Through the kindness of Prof. A. L. Day, of the University of the Philippines, I have examined some specimens from Cavite. The largest of these, with a length of 455 millimeters, is a female ready to spawn. Her body is markedly enlarged by the ripe ovaries, which extend for some distance behind as well as a long way before the anal opening. Unfortunately the date of collection is not known. This eel has also been recorded from the Philippines by both Richardson and Günther and from Manila by Jordan and Seale and by Jordan and Richardson.

This very large eel is abundant in the Manila markets, where specimens 2 meters in length are occasionally seen. Though originally described from the Red Sea it is very widely distributed and occurs from the east coast of Africa throughout the Indian Ocean and in the Pacific from Japan to Australia and the South Sea Islands; it is everywhere esteemed for food. Though primarily a marine species it occurs plentifully in the mouths of rivers and up them as far as the tides are felt.

Murænesox talabon (Cantor).

Conger talabon CANTOR, Journ. Asiat. Soc. Bengal **18** (1850) 1294.
Murænesox talabon BLEEKER, Atlas Ichth. Muræn. **4** (1864) 22, pl. 8, fig. 2; GÜNTHER, Cat. Fishes Brit. Mus. **8** (1870) 45; WEBER and BEAUFORT, Fishes Indo-Austr. Arch. **3** (1916) 255, figs. 103 and 105.
Muræneosox talabon DAY, Fishes of India (1878) 661, pl. 168, fig. 5.

Depth 17.8, head 6.56 in total length; head 4+; head and trunk 1.64 in tail, which is 0.62 of the total length; eye 3 in snout and 11.3 in head; cleft of mouth 2.27 in head, pectoral a little more than 3.

Measurements of two specimens of Muræneosox talabon.

	No. 9476.	No. 9495.		No. 9476.	No. 9495.
	mm.	*mm.*		*mm.*	*mm.*
Length	820	950	Eye	11	14.5
Depth	46	58	Snout	33	43
Head	125	155	Mouth	55	69
Trunk	185	219	Pectoral	40	49
Tail	510	576			

Teeth in upper jaw begin far behind snout, in three series, the outer one of minute teeth closely appressed against the much larger second row; inner row short, curved, and separated from outer row for most of its length by a wide interspace; intermaxillary plate with about six or eight canines around margin and a short row of smaller teeth in center; vomer with a central row of about eight or ten strong, sharp-pointed canines, without basal lobes, the posterior ones largest and roughened as if they might develop lobes, and two lateral rows of very small, irregular, and poorly developed teeth very close to the central row; teeth in mandibles in three rows, those of outer row small, closely set behind but apart, pointed, and turned more or less outward in first half of jaw; second row of very much larger and stronger, laterally compressed teeth, ending at front in four or five long, strong canines; inner row of minute teeth.

The general arrangement of the teeth is like that in Weber and Beaufort's figure, which does not agree with their text. The large teeth are subject to considerable variation, as in my specimens I can see that teeth have been broken out in some places and in others are only partly regrown.

The dorsal is very low in front and begins in advance of the gill opening; on the tail it is half or more than half as high as the body beneath; the anal is very low.

Trunk plump, rounded, becoming compressed on tail, which is greatly flattened posteriorly; snout sharp, very long and narrow.

Ashen gray to olive above, becoming darker on snout, paler on sides, and merging into white on belly, everywhere with a silvery sheen; belly and lower part of sides sprinkled thickly with dark dots; jaws and sides of trunk with a butter-yellow or golden tinge which extends over pectorals, these more or less dusky on inside; dorsal pale, with a yellowish cast, anal silvery whitish, each with a broad black margin; lateral line conspicuous, its origin below nape.

The larger of the two specimens cited above had a broad yellow-green band on the upper surface along the base of the dorsal; the sides were silvery with a golden luster on the head and body, this fading soon after death; the underside paler, becoming white on the throat and belly; the pectoral was pale lemon yellow, with a dusky blotch more or less evident on the inner side near the extremity.

A specimen seen in the Manila market was nearly 2 meters in length and had an exceedingly robust trunk, with a girth of about 375 millimeters.

The depth varies from 15 to 25 and the head is somewhat more or less than 6 times in the length; the eye is from 9 to 11.5 times in the head.

This large and powerful marine eel, which is said by Day to reach a length of 10 feet or more, occurs in the warm seas of the Orient and also enters brackish waters. It is frequently taken with *Muræenesox cinereus* in Manila Bay, though not in such numbers, and is not rare in the Manila markets, where it is highly prized for food.

Originally described in India, it is found in all the East Indies and north to the coast of southern China. The smaller of my specimens has the mesentery and body cavity infested with many small nematodes, concerning which nothing is known definitely. Similar worms may be observed in great numbers in various species of fish, a notable instance being the herring, abundant at times on the coast of California.

HETEROCONGRIDÆ

Greatly elongated scaleless eels, the trunk subcylindrical, with compressed, ribbonlike tail, nearly twice to more than twice as long as head and trunk together, not, as incorrectly stated by Weber and Beaufort, "nearly twice or more than twice in head and trunk;" dorsal and anal rather low, confluent with caudal; pectorals absent or minute; snout obtuse, very short, cleft of mouth oblique, not reaching eye or at most extending to a point below its front margin; lower jaw extending beyond upper; posterior nostrils in front and slightly below level of upper margin of eye; anterior nostrils very small, concealed; tongue free; teeth in jaws and on vomer small, acicular, arranged in bands; gill openings lateral narrow slits; lateral line present.

A rare family hitherto known from a single genus with one species in Amboina and one in the Canary Islands. The skeletal characters are unknown.

Diagnosis here altered from Weber and Beaufort, [6] to include a new Philippine genus and species.

Key to the genera of Heterocongridæ.

a^1. Pectorals absent .... **Heteroconger.**
a^2. Pectorals present .... **Tænioconger.**

[6] Fishes Indo-Austral. Arch. 3 (1916) 271.

Genus TÆNIOCONGER[7] novum

This genus differs principally from *Heteroconger* Bleeker in having pectoral fins; they are very small but plainly evident; the mouth is also smaller than in *Heteroconger;* the vomerine teeth are much thicker and stronger than those of the jaws; the upper lip forms a loose flap or fold turned back over the upper jaw; there is a similar flap on the lower jaw but it is less-well developed.

Type, *Tænioconger chapmani* sp. nov.

Tænioconger chapmani sp. nov. Plate 3.

An excessively elongated and slender eel, depth 86.25 in length; the elongated subcylindrical trunk passes gradually into the flattened, ribbonlike tail which is $2\frac{2}{7}$ times as long as head and trunk together; head small and short, its length a little more than 7 in trunk and a trifle more than 26.5 in total length, its greatest breadth $3\frac{5}{7}$ in its own length; the obtuse blunt snout about 6.5 in length of head; mouth wholly anterior, very oblique, not extending to eye; lower jaw same length as snout and projecting like that of a bulldog; eye very large, its diameter about one-fifth the length of head; posterior nostrils in front of eyes, about on a level with their upper margin.

Teeth very small, pointed, subequal, closely set; upper jaw with three rows anteriorly, becoming reduced to two and finally at rear to a single row of larger, needlelike teeth; vomer with six rows anteriorly, forming a broad patch and tapering posteriorly to a single row; vomerine teeth two or three times as coarse as and also somewhat longer than those in bands on jaws; mandibles with four rows of teeth anteriorly, these reduced to two rows posteriorly.

Gill openings nearer back than belly and wider than base of the minute pectorals which lie directly behind them; pectorals 4 in greatest depth of body and 13 in length of head; height of dorsal one-fourth of depth of body, its origin less than half the height of body behind gill openings; anal begins immediately behind vent; origin of lateral line on nape; a row of pores on lower jaw and along throat as far back as a point beneath origin of lateral line; two pairs of pores on snout in front of posterior nostril and a line of large pores curving under and around each eye to top of head.

[7] *Tænioconger*, from ταινια, a band; conger, an eel.

Here described from the type and only specimen, collected at Dumaguete about 1914, by the zoölogical department of Silliman Institute. The specimen was damaged by a thick fungal scum which covered the preservative in which the fish was kept, so that the eyes were destroyed and the lips damaged; the anterior nostrils were therefore not seen by me. The eyes were apparently covered by the skin in life. This singular eel is an unexpected addition to a little-known family, the only other East Indian representative having been described and figured by Bleeker from Amboina under the name of *Heteroconger polyzona*,[8] with a text figure.

The type and only specimen has the following dimensions: Length, 690 millimeters; head, 26; trunk, 184; tail, 480; greatest depth of body, 8; length of snout, 5; height of dorsal, 2; eye, 5.

Named for Dr. J. W. Chapman, professor of zoölogy in Silliman Institute, Dumaguete, Oriental Negros.

MYRIDÆ

This family is composed of scaleless, more or less wormlike eels, usually small and dull colored. Vertical fins confluent, while the pectorals may be well or poorly developed or altogether absent. Posterior nostrils usually near eyes in upper lip and covered by a valve or protruding flap; anterior nostrils in a short tube at margin of upper lip. Tongue more or less completely adnate; teeth small, in one or more series or bands. Gill openings small to very small. Anus in anterior half of length but far behind gill openings.

Fishes of the tropical and subtropical seas, living in coral reefs, on sandy coasts, or in the sea near them.

Represented in the Philippines by only one genus.

Genus **MURÆNICHTHYS** Bleeker

Murænichthys Bleeker, Verh. Bat. Gen. 25 (1853) Muræna 71.

Very elongate and slender, scaleless, cylindrical, more or less wormlike eels, without pectoral fins, tail comprising more than half the total length, and with both nostrils on margin of upper lip, the anterior tubular, the posterior at base of a pendulous flap; snout projecting somewhat beyond lower jaw; cleft of mouth extending more or less behind eyes; dorsal and anal very low, confluent around tail, dorsal beginning very far behind gill

[8] Versl. Med. Akad. Amsterdam (2) 2 (1868) 332.

openings, which are very small, lateral, and widely separated; teeth small, on vomer and jaws; a lateral line present.

Small marine eels occurring from the Red Sea to Japan, Australia, and the islands of the South Pacific.

Key to the Philippine species of Muræenichthys.

a^1. Origin of dorsal nearer gill openings than vent .... **M. macropterus.**
a^2. Origin of dorsal not nearer gill openings than vent.
  b^1. Vomerine teeth large, blunt, rounded; origin of dorsal nearer vent than gill openings; jaw teeth in two, three, or four rows. **M. gymnopterus.**
  b^2. Vomerine teeth small, sharp pointed; origin of dorsal midway between vent and gill opening. Jaw teeth uniserial.
    c^1. Vomer with two rows of teeth; eye 18 in head........ **M. thompsoni.**
    c^2. Vomer with teeth in one row, imperfectly two rowed or forming a Y; eye 11 to 14 in head.. **M. malabonensis.**

Muræenichthys macropterus Bleeker.

Muræenichthys macropterus BLEEKER, Act. Soc. Sci. Indo-Neerl. 2 (1857) 91; Atlas Ichth. Muræn. 4 (1864) 31, pl. 7, fig. 3; JORDAN and SEALE, Proc. U. S. Nat. Mus. 28 (1905) 772; CASTO DE ELERA, Cat. Sist. Fauna Filip. 1 (1895) 588; WEBER and BEAUFORT, Fishes Indo-Austral. Arch. 3 (1916) 275.

The following description is copied from Weber and Beaufort:

Height 27.5–40; head about 7.5, 2 to 2.2 in trunk. Head and trunk about 1.3 to 1.5 in tail. Eye 8–12, twice in snout. Cleft of mouth reaching behind eye. Origin of dorsal nearer to the gill openings than to anus; its distance from vertical through anus nearly 1.2–1.5 longer than head. Mandibulary and maxillary teeth small, subconical, in 2 series. Those on the vomer larger and more granular, in two close set series, on the intermaxillary plate is a semicircular row of similar teeth. Color of alcohol specimens brownish. Length 247 mm.

The only specimen I have seen is one that I determined in the museum of the University of Santo Tomas. It differs markedly from the description by Bleeker and from the one cited above in its stouter form, the depth being contained but 18.8 times in the length; the head is contained 8 times in the length and 2.75 in the trunk; the gape is contained 2.5 times in the head. Length, 160 millimeters; depth, 8.5; head, 20; tail, 85; gape, 8. In other respects, however, it is typical.

This specimen came from Mindoro Island; the species has also been recorded from southern Negros by Jordan and Seale.

Since writing the above I have received a specimen from Lingayen, Pangasinan Province, collected January 5, 1923. Its dimensions are as follows: Length, 185 millimeters; depth, 8; head, 28; tail, 110.

This unimportant East Indian species ranges from Singapore northeast to the Philippines, eastward in the Pacific to the Marshall Islands, and south to the Tonga group.

Muraenichthys gymnopterus Bleeker.

Muræna gymnopterus BLEEKER, Verh. Bat. Gen. 25 (1853) Muræna 52.

Muraenichthys gymnopterus BLEEKER, Verh. Bat. Gen. 25 (1853) Muræna 71, Atlas Ichth. Muræn. 4 (1864) 32, pl. 6, fig. 1; WEBER and BEAUFORT, Fishes Indo-Austr. Arch. 3 (1916) 276, fig. on page 418.

Muraenichthys microstomus BLEEKER, Atlas Ichth. Muræn. 4 (1864) 32, pl. 6, fig. 2.

Depth 23.4 to 33.1 in total length (34 to 25, Bleeker), 3.2 to 4.6 in head; head 1.8 to 2 in trunk, 7 to 8 in length; head and trunk together 1.36 to 1.57 in tail; eye from 0.5 to 0.6 as long as snout, 13 to over 15 in head; snout 6.5 to 8.5 in head, the wide mouth from 3.7 to 4.2; origin of dorsal nearer anus than gill openings, the distance being from a little less than down to 0.8 the length of head.

Vomerine teeth large, blunt, rounded, resembling those of the genus *Pisodonophis*, much larger than those of jaws, in two or four rows, or four rows anteriorly and two posteriorly; intermaxillary teeth usually continuous with vomerine, smaller, more or less pointed, and arranged in a semicircle, about six in number; maxillary teeth more or less irregular, usually with three rows, the teeth of the inner one like those of vomer but smaller, and an outer row of sharp-pointed teeth at rear; one small specimen has but two irregular rows of conical teeth; mandible with two rows of rather large blunt teeth and third short row near symphysis.

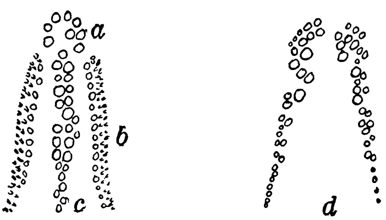

FIG. 2. *Muraenichthys gymnopterus* Bleeker, dentition; *a*, intermaxillaries; *b*, maxillaries; *c*, vomer; d, mandibles. × 3.

Small eels with narrow head and blunt, rounded snout, cylindrical body, and with posterior half of tail strongly compressed. A row of large pores on mandible, extending beyond angle of mouth and then curving upward; four pairs of pores on top of snout to eyes and on around them, one behind and two below each eye; lateral line beginning on nape.

Color of a living specimen pale creamy brown, thickly spotted above with minute dusky specks so as to be yellowish brown; belly cream color; a yellow band from chin to gill opening, then

along side, descending gradually and running along base of anal on each side; the caudal, posterior part of dorsal, and anal fin bright yellow; anterior part of dorsal clear, more or less minutely spotted. Color in alcohol dusky gray-brown above, paler to whitish or yellowish beneath, or else uniform brown, everywhere thickly spotted with minute dark specks except on throat and belly, which are therefore paler than rest of body; fins uniform pale gray or yellowish, slightly punctulated.

Measurements of four specimens of Muræenichthys gymnopterus from Manila Bay.

No.	Length.	Head.	Trunk.	Tail.	Depth.	Eye.	Gape.
	mm.	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*
656	190	26	52	112	6	2	7
834 [a]	298	42	79	177	—9	—3	10
9491	175	23	45	107	7	2	6+
	270	38	76	156	11.5	2.5	10

[a] A female nearly ready to spawn.

Without authentic specimens for comparison the disposition of this material is slightly uncertain; my specimens are strongly differentiated from closely related forms by the vomerine teeth, though none of the published descriptions of *Muræenichthys gymnopterus* go into details on the teeth further than that they are "conical, more or less obtuse." Weber and Beaufort state "cleft of mouth reaching more than 3 eye diameters behind eye," but this does not agree with their figure and is undoubtedly an error.

This insignificant East Indian eel attains a length of over 30 centimeters and is known from Java to China, the Philippines, and the Fiji Islands. It is frequently seen in the Manila fish markets, coming from the *bañgos* fishponds around Manila Bay, where it spawns in July.

There is a specimen from Mindoro in the museum of Santo Tomas, and Jordan and Seale recorded it from Cavite.

As this went to press I received a specimen from Dagupan, Pangasinan Province, having a length of 300 millimeters and a depth of 12 millimeters.

Muræenichthys thompsoni Jordan and Richardson.

Muræenichthys thompsoni JORDAN and RICHARDSON, Bull. U. S. Bur. Fisheries 27 (1907) (1908) 237, fig. 1.

Head 6.60; depth equal to distance from tip of snout to back of orbit; length of head and trunk equal to .80 of tail; snout 1.33 times eye; cleft

of mouth 2.75 in head, the maxillary extending a distance behind orbit equal to length of snout; eye 18 in head; dorsal origin almost exactly midway between vent and gill opening, the fin very low anteriorly; tail tapered to a sharp point, tipped with short caudal fin continuous with dorsal and anal; no pectorals; gill openings a distance behind eye equal to 2.25 times length of maxillary; vomerine teeth in two rows; teeth in jaws uniserial. Color in spirits light brownish, everywhere finely specked with darker, except on belly, which is pale.

This species is known to us from a single specimen, 3.75 inches long, collected in Manila Bay by Dr. J. C. Thompson, of the United States Navy, for whom the species is named. The type is no. 20201, Stanford University.

In its large mouth and in many other features this eel resembles *Murænichthys macrostomus* Bleeker, but the insertion of the dorsal is different.

In the description cited above the statement "depth equal to distance from tip of snout to back of orbit" is evidently an error, since the figure shows the ratio to be altogether different. I have not been able to recognize this species among the specimens of *Murænichthys* at my disposal.

Murænichthys malabonensis sp. nov. Plate 2, fig. 1.

Depth $3\frac{1}{7}$ to $5\frac{2}{3}$ in head and 21.5 to 39 in length; head 1.75 to 2 in trunk and 6.88 to 7.86 in length; head and trunk together 1.46 to 1.61 in tail, which is from 59 to 62 per cent of total length; eye from two-thirds to three-fourths the length of snout and 11 to 14 in head; mouth wide, reaching one or two diameters beyond eye, and 2.75 to 3.7 in head; origin of dorsal midway between gill openings and anus or, in one specimen, nearer anus, its distance from the latter being a sixth less than the length of head.

Teeth very small, conical, sharp pointed, in one row in jaws or, in one specimen, with anterior part of maxillary two rowed and mandible with two rows near symphysis; vomer with one row, or imperfectly two rowed, or with anterior part forming a very short Y followed by a long single row; teeth of intermaxillary plate separated from the others by a groove, forming an inverted V of about five larger teeth, or a small irregular group.

A small elongate eel, body subcylindrical, tail compressed, posterior portion strongly so; a double row of pores on snout, continued on around eyes and below them; a row of large pores on each side of mandible extending beyond angle of mouth, curving up behind it and on over nape, thus continuous with the lateral line, which originates there.

Color in alcohol uniform pale brown; densely punctulated with minute dark specks above the lateral line on trunk and over

entire tail, belly and throat therefore paler than the other parts; fins uniform pale yellowish or slightly punctulated.

I have examined four specimens, three of them females ready to spawn, taken from a bañgos pond at Malabon, Rizal Province, on the shores of Manila Bay.

Measurements of four specimens of Muraenichthys malabonensis from Malabon, Luzon.

No.	Length.	Head.	Trunk.	Tail.	Depth.	Eye.	Gape.
	mm.	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*
839 [a]	175	22	45	108	7	2	7
840 [a]	193	28	50	115	8	2	8
841 [a]	172	24	45	103	8	2	—9
842	117	17	30	70	3	1.5	5

[a] Female nearly ready to spawn.

The table shows the great relative difference in depth between the spawning females and the younger, less-mature individuals such as No. 842. In common with other small eels, they spawn at Manila Bay in midsummer, those of this particular species probably about the middle of July.

This species is very close to *Muraenichthys thompsoni* Jordan and Richardson, but differs from it in several particulars, such as larger eyes, greater slenderness, greater length of head and trunk in proportion to that of tail, etc. It differs very strongly from *Muraenichthys gymnopterus* in the dentition, less so in the position of the dorsal and in some minor points.

OPHICHTHYIDÆ

SNAKE EELS

Scaleless, elongate, true eels, having a wormlike or slightly compressed body, the end of the tail extending beyond the vertical fins (which may be well developed, very small or altogether wanting) and lacking even the rudiments of a caudal fin. The pectorals may be fully developed or degraded and entirely absent. The anterior nostrils are in a tube or papilla in the upper lip and open downward. The posterior nostrils are an opening on the inner side of the upper lip within a tumid flap forward of or beneath the front margin of the eye. In a few of the genera the upper lip is fringed with a mustachelike row of barbels while in a number of genera there are two pairs of teatlike papillæ on the upper lip. The tongue is fastened more or less completely to the floor of the mouth. The gill openings are not confluent

and may be large or small, lateral or ventral. Eggs numerous, of medium size, resembling those of ordinary fishes.

Found in temperate and tropical seas throughout, in shallow water on coral reefs and sandy shores, often burrowing. Some species enter fresh-water streams. The genera and species are numerous; the individuals are usually small or medium sized and abound in the crevices of coral reefs. The species are often gaily blotched or banded so that they startlingly resemble true serpents.

By Ilocanos these eels are called *quinet;* in Tagalog they are known as *igat, palos,* and *pindangá;* the Visayans use the names *ucdoc,* or *ógdoc,* and *taguibolos;* the Moros call them *taguibus.*

Key to the genera of Ophichthyidæ.

a^1. Brightly colored, spotted, banded, or variegated.
b^1. Vomer with teeth.
c^1. Dorsal and anal extending almost to tip of tail.......... **Myrichthys.**
c^2. Dorsal ending about the length of head before tip of tail, anal twice length of head or more.......... **Chlevastes.**
b^2. No teeth on vomer.......... **Leiuranus.**
a^2. Philippine species all dull colored.
d^1. Upper lip with a fringe of barbels.......... **Cirrhimuræna.**
d^2. Upper lip without barbels.
e^1. Pectorals present, gill openings lateral.
f^1. Teeth blunt, conical or granular, in bands.......... **Pisodonophis.**
f^2. Teeth pointed, sharp, in one or more series.......... **Ophichthus.**
e^2. Pectorals absent.
g^1. Gill openings ventral, longitudinal or oblique, and with a duplication of the gill membranes anteriorly.......... **Lamnostoma.**
g^2. Gill openings more or less lateral, vertical, transverse or oblique, gill membranes not duplicated by a false fold.......... **Caecula.**

Genus **MYRICHTHYS** Girard

Myrichthys GIRARD, Proc. Acad. Nat. Sci. Phila. (1859) 58.

A small group of slender, much-elongated eels, distinguished from other closely related genera by having the dorsal and anal fins extend almost to the tip of the tail.

Head small and conical, with a short, pointed, convex snout which overlaps mouth; anterior nostrils in tubes on the flattened lower surface of snout; posterior nostrils wide, concealed in upper lip just below or slightly forward of anterior margin of each eye, and opening downward; tongue adnate; teeth blunt, conical, small, the posterior ones often very small, in two rows in jaws and on vomer; dorsal beginning on nape far in advance of gill openings, both dorsal and anal fins extending almost to tip of tail; pectorals very short and barely visible.

Small reef-dwelling eels occurring throughout the tropical seas, the species few.

Myrichthys maculosus Cuvier. Plate 10, fig. 2.

Muræna maculosa CUVIER, Regne Animal 2 (1817) 232, note 3.
Ophisurus maculosus RICHARDSON, Zool. Voyage Erebus and Terror, Fishes (1844–48) 102.
Ophisurus ophis BLEEKER, Atlas Ichth. Muræn. 4 (1864) 65, pl. 16, fig. 3.
Ophichthys maculosus GÜNTHER, Cat. Fishes Brit. Mus. 8 (1870) 81; Fische d. Südsee (1910) 401.
Myrichthys maculosus WEBER and BEAUFORT, Fishes Indo-Austr. Arch. 3 (1916) 284, fig. 129.

Depth 38 to 47 in length; head 14.5 to 17 in length and 5 to 6 in trunk; head and trunk together much shorter than tail, being from two-thirds to three-fourths as long as the latter; eye 8 to 9 in head and 1.5 to 2.5 in the broad, convex snout; mouth moderately large, extending well beyond eye, 3 to 4 in head; dorsal commencing on nape, the vertical fins extending almost to tip of tail; pectorals very small, rounded, their length 6.5 to 10 in head. Teeth on intermaxillary plate largest, conical, about six in number; vomerine teeth in two rows, blunt, conical, extending much farther backward than those in jaws; maxillary teeth small, the forward half in two rows, posteriorly in one row; lower jaw teeth in two rows, the forward ones larger than those at back of mouth.

White or whitish, with three rows of alternating circular brown spots, the middle row largest, the other rows extending on to fins.

A handsome, slender eel, reaching a length of 1 meter. I have examined a specimen in the collection of the Ateneo de Manila, obtained in Surigao, Mindanao, having the following dimensions: Length, 311 millimeters; head, 21; trunk, 109; tail, 181; gape, 7.5; eye, 2.25; snout, 4; pectoral, 3; depth, about 40 in length.

This eel is evidently a greedy feeder, as the belly of this specimen was lumpy with masses of freshly captured prey while the tail of a partly swallowed shrimp projected from its throat.

After the above had been written a fine specimen, 528 millimeters in length, was added to the Bureau of Science collection. It was obtained at Iba, Zambales, February 4, 1922, by Mr. H. R. Montalban. In life the ground color was yellow; this has gradually faded until now it is little evident.

Mr. G. A. Lopez, of the Bureau of Science, also collected a specimen, 370 millimeters long, at Cabalian, Leyte, May 26, 1922.

A marine, reef-dwelling species occurring from Madagascar to the East Indies and on to the South Sea Islands.

Genus **CHLEVASTES** Jordan and Snyder

Chlevastes JORDAN and SNYDER, Proc. U. S. Nat. Mus. **23** (1901) 867.

Elongate, snakelike, the vertical fins low, the dorsal beginning on top of head far in advance of gill openings and ending the length of head before tip of tail; anal ending far before end of dorsal, at least twice the length of head, if not more, before tip of tail; teeth mostly blunt, granular or molar, in two series on jaws and vomer; those of intermaxillary in a group of eight or nine, separated from the rest by an interspace and situated in a furrow between nostrils; pectorals rudimentary.

One species, widely distributed in the tropical seas of the eastern hemisphere. This genus is very close to *Myrichthys*, of which it is made a subgenus by Weber and Beaufort, and differs principally in the disappearance of the anal fin far before the tip of the tail.

Chlevastes colubrinus (Boddaert). Plate 4.

Muræna colubrina BODDAERT, in Pallas, Neue Nord. Beytr. **2** (1781) 56, pl. 2, fig. 3.

Ophisurus fasciatus BLEEKER, Atlas Ichth. Muræn. **4** (1864) 65, pl. 21, fig. 1.

Chlevastes colubrinus JORDAN and SNYDER, Proc. U. S. Nat. Mus. **23** (1901) 867.

Myrichthys (Chlevastes) colubrinus WEBER and BEAUFORT, Fishes Indo-Austr. **3** (1916) 285, figs. 130, 131.

Chlevastes fasciatus JORDAN and SEALE, Bull. U. S. Bur. Fisheries **25** (1905) 195, fig. 5.

Chlevastes elaps FOWLER, Proc. Acad. Nat. Sci. Phila. **64** (1912) 13, fig. 3.

In a specimen from Dumaguete, Oriental Negros, having a length of 555 millimeters, the depth is 55.5 in total length; length of head, 28 millimeters; diameter of eye, 2.5; length of head and trunk together, 248; tail, 307; dorsal fin terminates 18 millimeters from tip of tail; anal terminates 59 millimeters from tip of tail. This eel has thirty complete black rings, the first ring on the snout being connected with the second by a broad black band on the underside, the rings all wider than the

interspaces; ground color of body ivory white to brownish white; tip of snout and tip of tail white.

In another specimen, from Puerto Galera, Mindoro, with a length of 628 millimeters, the depth is but 9 millimeters, being thus almost one-seventieth of the total length; head 32 millimeters long, $19\frac{5}{8}$ in total length; head and trunk together 290 millimeters; tail, 335; origin of dorsal 14 millimeters behind tip of snout, or much nearer snout than gill opening; diameter of eye 2.5 millimeters; gape, 9; mouth extends about a diameter beyond eye; dorsal ends 37 millimeters before tip of tail; the anal, 72.

This specimen has thirty-one narrow chestnut brown rings with very much wider pale or whitish tan interspaces, and one or two large circular or irregular chestnut brown spots on each side, or else an incomplete ring in each interspace. This is the variety *fasciata* Günther or *oculata* Bleeker.

A third specimen, from Iba, Zambales, measures 545 millimeters in length and has twenty-eight rings, with occasionally a circular spot between them.

Height 52 to 70 in total length, head, 18 to 21; eye 10 to 14 in head; pectoral fin is reduced to a minute vestigial flap; dorsal fin begins much nearer tip of snout than gill opening; the whole fish is pale, whitish to brown, with from twenty-six to thirty-three black or brown rings which include the fins, tip of snout and of tail being white or light colored; the interspaces may vary greatly in width and may be spotted or blotched in various ways, as in the variety described above, or in the variety *elaps* Fowler, where the broad interspaces contain one to five brown spots or blotches. In the variety *semicincta* Bleeker some or most of the dark rings fail to meet around belly.

This striking-looking eel reaches a length of nearly 1 meter and is particularly snaky looking as it creeps around the crevices of coral reefs. It bears a remarkable resemblance to *Leiuranus semicinctus,* the two species often living in the same hole.

This species occurs from the Red Sea and Zanzibar north to the Riu Kiu Islands, throughout the Indo-Australian Archipelago, and in the western Pacific to Tahiti and New Zealand.

Genus **LEIURANUS** Bleeker

Leiuranus BLEEKER, Verh. Bat. Gen. **25** (1852) Muræna 36.

Small, elongate, scaleless, cylindrical eels, with small pectorals and no caudal, the vertical fins low and not confluent; head small, the long, pointed, projecting snout flattened on lower side,

from which hang the tubes of the anterior nostrils; posterior nostrils opening downward in upper lip, concealed by a flap; mouth small, weak, the gape extending little if any beyond eye; tongue adnate; teeth small, pointed, in two rows on maxillaries and one on mandible; none on vomer; lateral line present; gill openings small, vertical, lateral slits, separated by a broad interspace.

Delicate, graceful, brightly colored eels, separated from *Ophichthus, Chlevastes,* and other closely related genera by the absence of teeth on vomer. Found throughout Malaysia to the Riu Kiu Islands, Australia, Hawaii, and the South Sea Islands.

Leiuranus semicinctus (Lay and Bennett).

Ophisurus semicinctus LAY and BENNETT, Beechey's Voyage Blossom (1839) 66, pl. 20, fig. 4.

Leiuranus semicinctus GÜNTHER, Cat. Fishes Brit. Mus. **8** (1870) 54; JORDAN and SNYDER, Proc. U. S. Nat. Mus. **23** (1901) 866; WEBER and BEAUFORT, Fishes Indo-Austr. Arch. **3** (1916) 294, fig. 137.

I have examined two specimens of this pretty little snakelike eel; one, 360 millimeters long, from Dumaguete, Oriental Negros, and the other from Sitanki with a length of 278 millimeters. While they agree in most respects with the published accounts, they differ in some particulars: Body elongate, nearly or quite cylindrical, its depth 46 to 60 in total length (46 to 55 in published descriptions); length of head 12 to 15 in total length, 5.6 to more than 6 in trunk. According to authors the head and trunk are one-seventh longer than the tail, but in my specimens the tail is longer. In the smaller one the head and trunk measure 132 millimeters, the tail, 146; in the larger one, 174 and 186, respectively.

Eye small, 1.5 to 2 in snout, which projects one-eighth the length of head beyond mouth; jaws feeble, delicate, gape extending to posterior border of eye or a trifle beyond; pectorals small, about twice eye; dorsal beginning over pectorals; vertical fins low, not quite reaching tip of tail.

The arrangement and shades of color are variable. The Sitanki specimen is yellow and brown in alternate narrow pale yellow and wide dark brown bands; the latter, of which there are twenty-six, do not extend more than halfway down the sides, except the last two on the tail. The other specimen has twenty-six wide dark brown bands which do not meet below, but the interspaces and belly are very pale, almost white. Weber and Beaufort say "black bands continued on fins," but in my specimens the dorsal is all pale.

In general, alcoholic specimens are cream colored to whitish brown, with from twenty-one to thirty-five broad dark brown to blackish bands, much wider than the interspaces; the dark bands may or may not meet below, but often do so on the tail. The tip of the snout and tail are usually pale, but in my larger specimen the tip of the snout is dark.

This species bears a remarkable resemblance to *Chlevastes colubrinus,* with which it dwells in the coral.

A marine species found on coral reefs and along shore, occurring from the Riu Kiu Islands to Queensland, and from the Hawaiian Islands to the Samoan and Fiji groups.

Genus CIRRHIMURÆNA Kaup

Cirrhimuræna KAUP, Uebersicht der Aale, Archiv. für Naturg. 22 (1856) 52; Cat. Apod. Fishes Brit. Mus. (1856) 27.

Small, slender, elongate, cylindrical eels distinguished from all related forms by the fringe of short, irregularly formed, mustachelike barbels on upper lip; dorsal beginning above or slightly before or behind gill openings; pectorals well developed; head small, elongated, the narrow and pointed snout projecting beyond the large mouth, which extends backward far behind the small eye; teeth small, needlelike, uniform or rarely the inner row larger, mostly depressible, pointed backward, in bands on jaws and vomer, those on intermaxillary plate in a separate group; anterior nostrils short tubes projecting downward and located on each side of snout about a third of the distance from its tip to eye; posterior nostrils opening on inner side of upper lip, just forward of eye or below its front margin; tongue adnate; gill openings small, in front of and somewhat below base of pectorals; a lateral line present; anus in anterior half of length, tail very much longer than head and trunk.

Species few and poorly differentiated; the five nominal ones of the East Indies are probably reducible to two, though more material is necessary to clear this problem. Found from the Red Sea, Zanzibar, and Madagascar to the Philippines, China, and Australia.

Key to the species of Cirrhimuræna.

a^1. Maxillary teeth in two rows, the inner one larger..................... **C. oliveri.**

a^2. Maxillary teeth of uniform size, in three to six rows.

b^1. Vomerine teeth biserial; cleft of mouth about 3 in head. **C. tapeinopterus.**

b^2. Vomerine teeth in three or four rows; cleft of mouth about 2.5 in head. **C. chinensis.**

Cirrhimuræna oliveri (Seale). Plate 2, fig. 2.

Jenkinsiella oliveri SEALE, Philip. Journ. Sci. § A 4 (1909) 493.

Depth 40 in length, head 13.4; head 3.57 in trunk; head and trunk 1.79 in tail, which is 1.55 in total length; eye 1.8 in snout and 10.4 in head; snout 5.77 in head; gape 2.88 in head, pectoral $3\frac{5}{7}$.

A very elongate cylindrical little eel at once distinguished by its greater slenderness, by the origin of the dorsal being about the length of the pectorals forward of gill openings, and by the teeth, which differ strongly from those of any other species I have examined. Jaw teeth in two rows, the inner row of the maxillaries noticeably larger; vomerine teeth in two rows, merging into one row posteriorly; four pairs of teeth on intermaxillary plate; vertical fins low, the greatest height of dorsal slightly more than half the depth of body; a distinct pore above and somewhat before eye, another behind center of eye; fringe of upper lip beginning immediately behind anterior nostril; lateral line beginning on nape.

Color, light yellowish brown above, yellow below median line, belly whitish, sides finely punctulate with minute black specks, throat white, top of head brown, these two colors uniting in a sharp line on the middle of side of head, extending from angle of fins [= jaws] to gill openings; tip of snout and anterior portion of dorsal darker.—*Seale.*

I have examined the type and only specimen, Bureau of Science collection No. 4299, collected by Mr. Seale in Zamboanga, and find it to have the following dimensions: Length, 360 millimeters; head, 26; trunk, 103; tail, 231; eye, 2.5; snout, 4.5; gape, 9; pectoral, 7.

Seale states "head 5.10 in body; gape 1.75 in head," but my measurements do not tally with his. He likewise states that the dorsal and anal fins extend to the tip of the caudal, but I find they both stop before the tip of the tail, as in all other ophichthyoid eels I have ever examined. In his color description I have changed the word "fins" to jaws, as fins is evidently a typographical error.

Cirrhimuræna tapeinopterus Bleeker.

Cirrhimuræna tapeinopterus BLEEKER, Ned. Tijdschr. Dierk. 1 (1863) 183; Atlas Ichth. Muræn. 4 (1864) 41, pl. 8, fig. 3; WEBER and BEAUFORT, Fishes Indo-Austr. Arch. 3 (1916) 291, fig. 136.

Ophichthys tapeinopterus GÜNTHER, Cat. Fishes Brit. Mus. 8 (1870) 75.

Ophichthus tapeinopterus JORDAN and SEALE, Bull. U. S. Bur. Fisheries 26 (1906) (1907) 6; JORDAN and RICHARDSON, Bull. U. S. Bur. Fisheries 27 (1907) (1908) 238.

Jenkinsella nectura JORDAN and SEALE, Bull. U. S. Bur. Fisheries 26 (1906) (1907) 6, fig. 1 (typ. err.).

Depth 2.38 to 3.4 in head and 23 to 34 in total length; head 9.6 to 10.2 in length and 2.24 to 2.5 in trunk; head and trunk together 1.86 to 2 in tail which is therefore about 1.5 in total length; eye from 11.6 to 16 in head and from about 1.5 to 2 in snout, which is 6.8 to 9.66 in head; mouth reaches far behind eyes, its cleft from 2.6 to 3 in head; pectorals 2 to 2.38 in head; origin of dorsal ranges from above gill openings to above first fifth of pectorals.

Teeth small, uniform in size, needlelike, those in maxillaries in bands of three to five rows, broadest posteriorly, those on vomer usually in a narrow biserial band; this is sometimes irregular or in one row forward and two rows farther back, and in one specimen but one row is present; the vomerine band is shorter than the maxillary bands; teeth in mandibles small to very small, the band narrow, biserial or becoming uniserial; teeth on intermaxillary plate minute, few, four to six, more or less irregularly paired.

The head of this delicate little eel is narrow, the slightly convex snout sharp and pointed; lower jaw noticeably thin, flat, and weak; body cylindrical, tail full and rounded, becoming compressed only near its tip; lateral line beginning on nape.

Color in life usually semitranslucent pale cream gray, shading to ivory beneath, or very pale gray-brown, or sometimes olive above; upper half of body densely sprinkled with minute dusky dots which obscure the ground color, fins colorless or more or less slightly sprinkled with dots. Color of alcoholic specimens similar but darker, or finally uniform clear light brown, the

Measurements of ten specimens of Cirrhimuræna tapeinopterus from Manila Bay.

Length.	Head.	Trunk.	Tail.	Depth.	Length.	Head.	Trunk.	Tail.	Depth.
mm.	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*
170	17	40	113	5	[a] 264	26	66	172	10
172	18	42	112	5.5	[a] 279	29	66	184	10
201	22	47	132	8	296	29	72	195	9
233	24	55	154	8	[a] 300	31	73	196	13
[a] 241	25	56	.160	10	[a] 301	31	70	200	10

[a] Gravid female ready to spawn; the eggs are evidently laid in June or July.

upper half of body darkened by minute dots densely scattered over it, these few or absent below; throat much paler; fins unspotted or very lightly dotted, yellowish, paler than body.

This is a common eel in Manila Bay and the bañgos fish ponds, and is often seen in the Manila fish markets, where I have obtained many living specimens. All the specimens described by Jordan and his colleagues have been from Manila Bay. In the museum of the University of Santo Tomas is a specimen labeled Mindoro. Elsewhere it is known from Java, Celebes, and Flores, and undoubtedly occurs in shallow sandy bays and brackish waters throughout the Philippines.

I am unable to separate this species and *Jenkinsiella nectura*. The figure of the last named does not agree with the description but does agree fairly well with the present disposition.

Cirrhimuræna chinensis Kaup.

Cirrhimuræna chinensis KAUP, Cat. Apod. Fishes Brit. Mus. (1856) 27; WEBER and BEAUFORT, Fishes Indo-Austr. Arch. 3 (1916) 292, figs. 134, 135.

Cirrhimuræna polyodon BLEEKER, Atlas Ichth. Muræn. 4 (1864) 41, pl. 8, fig. 1.

Ophichthys chinensis GÜNTHER, Cat. Fishes Brit. Mus. 8 (1870) 75.

Depth 28.4 to 35 in length, head 8.5 to nearly 9.5; head 2.25 to 2.4 in trunk; head and trunk together 1.7 to about 2 in tail; eyes about 2 in snout and 16 to 19 in head; mouth reaching far behind eye, 2.5 to 2.7 in head; pectorals more than 2 in head; teeth fine, needlelike, in four to six rows on maxillaries, most numerous posteriorly; a band of three or four rows on vomer; teeth on mandibles very minute, the bands reduced, becoming a single row of larger teeth posteriorly; intermaxillary plate with a group of nine or ten teeth as in Weber and Beaufort's figure; lateral line beginning on nape; vertical fins low, dorsal beginning over or slightly behind gill opening, posteriorly emarginate and much the highest near tip of tail, somewhat as in Bleeker's figure.

Color brown above, paler on belly, very light on throat, and light brown on underside of tail.

I have placed here a badly preserved specimen collected at Cavite in 1907. It is a female nearly ready to spawn and is therefore stouter than the specimens described by authors. Its dimensions are as follows: Length, 370 millimeters; head, 39; trunk, 96; tail, 235; depth, 13; eye, 3; snout, 6; gape, 15.

There is also a specimen in the museum of the University of Santo Tomas, from Manila Bay.

This species is found on coral reefs and along shore and is said to occur from Madagascar to China and the Philippines.

Genus **PISODONOPHIS** Kaup

Pisodonophis KAUP, Uebersicht der Aale, Arch. für Naturg. 22 (1856) 47.

Much elongated, cylindrical eels with the origin of dorsal above or behind the well-developed pectorals; head of medium size, the pointed snout projecting beyond mouth, the cleft of which reaches below hind border of eye or beyond; eyes small, in the first third or fourth of head; posterior nostrils a slit on inner side of upper lip, below or in advance of front border of eye; anterior nostrils a short tube on edge of snout; teeth blunt, granular, subequal, in several series forming bands; those on intermaxillary plate in a group next to or separated from the other teeth; gill openings moderate or small, before and somewhat below base of pectorals; lateral line present; anus in or behind middle of length.

Slender, plainly colored fishes occurring from the Red Sea and Madagascar to Japan, Australia, and Samoa. Kaup's original spelling has been followed.

Key to the species of Pisodonophis.

a^1. Origin of dorsal well behind tip of pectorals.................................. **P. boro.**
a^2. Origin of dorsal over middle of pectorals or before........ **P. cancrivorus.**

Pisodonophis boro (Hamilton Buchanan).

Ophisurus boro HAMILTON BUCHANAN, Fishes Ganges (1822) 20, 363.
Pisoodonophis boro BLEEKER, Atlas Ichth. Muræn. 4 (1864) 62, pl. 20, fig. 3; WEBER and BEAUFORT, Fishes Indo-Austr. Arch. 3 (1916) 297, figs. 138, 140, 141.
Ophichthys boro GÜNTHER, Cat. Fishes Brit. Mus. 8 (1870) 77.

Depth 32 to 41.5 in length, head 9 to 12.5 in length and 3.2 to 3.6 in trunk; head and trunk a little more or less than 1.5 in tail (in my specimens 1.59 and 1.63); eye prominent but small, 8.8 to 12.5 in head (to 17, Weber and Beaufort), 1.3 to a little more than 2 in snout, which is depressed, projecting much beyond mouth, the tip blunt; tube of anterior nostrils more than half the diameter of eye, the posterior nostrils under front margin of eyes; mouth wide, extending well beyond eyes, 3.3 to 3.5 in head; the tumid upper lip overlaps upper jaw and intermaxillary teeth, as in many other Ophichthyidæ; pectorals 4 to 4.5 in head; origin of dorsal more than twice the length of pectoral behind gill opening; both vertical fins very low; teeth

granular, blunt, conical, or rounded, those on maxillaries in bands of four somewhat irregular rows; those on intermaxillary plate much larger, about a dozen in my examples but often more numerous and forming a large oval group of very coarse teeth; vomerine teeth continuous with those on intermaxillary, forming a long four-rowed band extending farther back than those in jaws; teeth on mandibles in bands of two rows, becoming three rowed and coarser at symphysis. The teeth in older specimens are much coarser and the bands wider than in the younger ones, so that there is great variation.

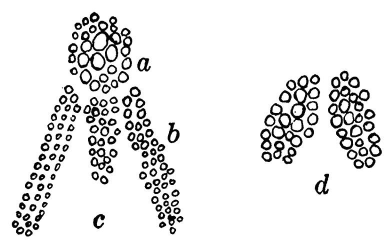

FIG. 3. *Pisodonophis boro* (Hamilton Buchanan), dentition; *a*, intermaxillary plate; *b*, maxillaries; *c*, vomer; *d*, mandibles. × 2. After Weber and Beaufort.

Four pairs of conspicuous pores on snout, the last opposite middle of eyes; similar pores on upper lip and curving up around eye; a row on lower jaw and two behind and a little below rictus; origin of lateral line far forward, on occiput.

Color of alcoholic specimens a dark leaden hue above, merging into pale, almost white below, everywhere densely punctulate with myriads of fine dark dots; also blackish brown above, lighter below.

Here described from two specimens, 513 and 598 millimeters long, in the Bureau of Science collection, collected at Alaminos, Pangasinan Province, through the kindness of Mr. Eugenio Fénix. I have also seen a very fine specimen in the Santo Tomas museum, having a length of 705 millimeters, which was obtained from Manila Bay. This species has been recorded from "Zebu" (Cebu) by Günther and from "the Philippines" by Fowler.

Since this went to press Chaplain Joseph Clemens collected a fine specimen, 780 millimeters long, at San Fernando, Pampanga, and I obtained one at Vigan, Ilocos Sur, 1,035 millimeters long.

This eel is found in both salt and fresh water, ascending rivers for some distance. It occurs from British India throughout the East Indies to New Guinea, the southern coast of China, and Formosa.

Pisodonophis cancrivorus Richardson.

Ophisurus cancrivorus RICHARDSON, Voyage Erebus and Terror, Fishes (1844) 94, pl. 50, figs. 6–9.

Pisoodonophis cancrivorus KAUP, Cat. Apod. Fishes Brit. Mus. (1856) 15; JORDAN and RICHARDSON, Bull. U. S. Bur. Fisheries 27 (1907)

(1908) 238; WEBER and BEAUFORT, Fishes Indo-Austr. Arch. 3 (1916) 300.

Pisoodonophis zophistius JORDAN and SNYDER, Proc. U. S. Nat. Mus. 23 (1901) 868, fig. 15.

Pisoodonophis macgregori JORDAN and RICHARDSON, Bull. U. S. Bur. Fisheries 27 (1907) (1908) 238, fig. 2.

Depth 22 to 35.78 in total length; head 8 to 10 in total length and 2 to more than 3 in trunk; head and trunk together from 0.63 to 0.7 of tail and 1.4 to 1.6 in tail, which is 1.6 to 1.7 in total length; eye 8 to 12 in head, and 1.6 to 2 in snout; gape 2.7 to more than 3.5 in head; pectoral contained about 3 to 4 in head; origin of dorsal varies from a point over gill opening to 0.5 the length of pectoral from origin of latter. Teeth granular or rounded, mostly uniform in size, arranged in triserial bands on jaws and a biserial band on vomer; soft palate and lips overlapping bands so that they appear narrower than they really are; teeth on intermaxillary plate numerous, more or less separated from the other teeth by a slight interspace; Richardson says "nasal disk circular, armed with about 15 crowded . . . teeth," but I find from eight to ten, usually arranged in pairs, the second and third pairs largest; they are so covered over by the nasal tubes and lips as to be difficult to observe. A small papilla protrudes from a notch in the upper lip about halfway between the anterior nostril and the eye, and a similar but much smaller one is below the eye immediately behind the posterior nostril; there are rows of large mucus pores along the jaws and behind the eye, as shown in the figures cited above. Richardson states there are "three on each side of the snout above and before the eye" but he missed another pair which lies between the eyes, directly opposite the pupils. One of my specimens has pores behind the angle of the jaw exactly as in Jordan and Snyder's figure of *P. zophistius;* some have one or two, but most of the specimens lack them altogether.

Color in life dusky brownish above, paler yellowish below; in alcohol varying from very pale yellowish to dark brown, paler below; nearly all specimens are thickly sprinkled with minute dark brown dots as in Jordan and Richardson's figure of *Pisoodonophis macgregori.* Dorsal and anal edged more or less with blackish, the dorsal sometimes with a dusky spot near its origin; pectorals all pale in my specimens and in one specimen all the fins are colorless.

This eel is found in the seas, bays, and brackish waters from Arabia and Madagascar to Japan, Australia, and the Samoan

Islands, and attains a length of nearly a meter. I have examined numerous specimens, ranging in length from 268 to 662 millimeters, from Manila Bay, Dumaguete, and Mindanao. Previously listed in the Philippines from Manila Bay and from Cuyo Island. This eel and similar Ophichthyidæ are frequently seen in the markets and are much esteemed as food, all of them being known in Tagalog as *igat,* though the name *pindangá* is also sometimes applied.

Genus **OPHICHTHUS** Ahl

Ophichthus AHL, De Muraena et Ophichtho (1789) 3; JORDAN and SNYDER, Proc. U. S. Nat. Mus. 22 (1901) 871.

Ophichthys BLEEKER, Günther, and most recent authors (corrected spelling); WEBER and BEAUFORT, Fishes Indo-Austr. Arch. 3 (1916) 300.

Much-elongated and cylindrical snakelike eels, the tail often bulkier and deeper than the trunk, separated from closely related genera by their conical, sharp, subequal teeth, without canines, in one or more series in jaws and on vomer; teeth of intermaxillary plate in a group, in pairs, or in a row of single teeth, separated from the other teeth; pectoral fins well developed; origin of dorsal behind head, and may be above gill openings or the pectorals, or slightly behind end of latter; both dorsal and anal end a short distance before tip of tail; gill openings small or medium sized, in front of and somewhat below base of pectorals; the pointed snout usually projects beyond mouth, the cleft of which reaches below hind border of eye, or beyond; upper lip with two prominent papillæ on each side; a lateral line present; anus somewhat before or much behind the middle of length.

In most representatives of this genus the color is more or less uniform brown, varying from glistening light brown to blackish brown, becoming paler on belly and throat, which may be gray or whitish; a close examination shows that the color is due to a vast number of minute brown or blackish dots thickly sprinkled over the back, sides, and fins; where they are less numerous or absent, as on the throat, the ground color alone shows.

A large genus, found throughout the tropical seas, the species very numerous.

The teeth on the intermaxillary plate are, in most species, much beyond the tip of the lower jaw and would therefore seem to be useless appendages. Whatever function they may fulfill, if any, they are subject to numerous irregularities in number and arrangement, and are apparently often broken or damaged,

judging from the appearance of numerous specimens I have examined. While they may be a useful diagnostic character, their value as such is not determinative but merely corroborative.

Key to Philippine species of Ophichthus.

a^1. Maxillary teeth in one row or posteriorly in two rows.
  b^1. A broad black crossband on nape, broadly edged with white or yellowish .... O. cephalozona.
  b^2. Coloration uniform.
    c^1. Depth less than 40 in length; head less than 3 in trunk.
      d^1. Vomerine teeth in two rows .... O. grandoculis.
      d^2. Vomerine teeth in two rows anteriorly, one row posteriorly. O. apicalis.
    c^2. Depth over 40 in length.
      e^1. Vomerine teeth anteriorly in two rows; posteriorly in one. O. macrochir.
      e^2. Vomerine teeth in two rows or anteriorly in three. O. manilensis.
a^2. Maxillary teeth in two rows.
  f^1. Vomerine teeth in two rows anteriorly, one row posteriorly. Depth 46 to 50 in length .... O. rutidodermatoides.
  f^2. Vomerine teeth in two rows anteriorly, three rowed posteriorly. Depth 30 to 36 in length .... O. celebicus.

Ophichthus cephalozona (Bleeker).

Ophichthys cephalozona BLEEKER, Atlas Ichth. Muræn. 4 (1864) 49, pl. 12, fig. 2; GÜNTHER, Fische d. Südsee 3 (1910) 398; WEBER and BEAUFORT, Fishes Indo-Austr. Arch. 3 (1916) 303, figs. 143 and 144.
Ophichthus cephalozona JORDAN and SNYDER, Proc. U. S. Nat. Mus. 23 (1910) 872.

Depth 28 to 33 in total length, head 10 to 11, and 3.5 to 4.5 in trunk; head and trunk usually less than tail (contained 1.8 times in it in my specimen), but according to Günther the tail may be either longer or shorter than body. Eye 10 to 11 in head, 1.75 to 2 in snout, which is bluntly pointed and projecting and about 5.5 in head; gape 3 to 3.5 in head and reaching slightly behind eyes; tubes of anterior nostrils prominent, projecting downward; posterior nostrils just forward of eyes, with a small papilla before and a minute one behind each; pectorals small, from more than 3 to 4 times in head; one pair of pores on tip of snout followed by four pairs extending back on

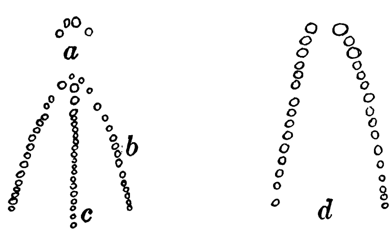

FIG. 4. *Ophichthus cephalozona* (Bleeker), dentition; *a*, intermaxillary plate; *b*, maxillaries; *c*, vomer; *d*, mandibles. × 2.5.

top of head to opposite pupil of eye; pores on sides of head and behind mouth as in Bleeker's figure. Teeth on premaxillary plate large, stout, pointed, forming a separate group of two or six; teeth in jaws and on vomer in one row, pointed, curved, fixed, those in front of lower jaw larger.

Color in alcohol a yellowish brown, paler beneath; a large broad blackish band on nape, with a broad pale yellowish band before and a narrower pale band behind it; dorsal beginning above posterior end of pectoral; both dorsal and anal with brownish base, a black or dark line along middle, and very pale margin.

I have examined one specimen taken at Cavite, with a length over all of 432 millimeters. Recorded also from Cebu by Günther. This distinctly marked species attains a length of almost a meter and occurs throughout the East Indies, northward to Japan, south and eastward to the Pelew Islands, North Australia, and the Tonga Islands.

Ophichthus grandoculis (Cantor).

> *Ophisurus grandoculis* CANTOR, Cat. Malayan Fishes, Journ. Roy. Asiat. Soc. Bengal **18** (1849) 324, pl. 5, fig. 3 (teeth).
> *Ophichthys grandoculis* BLEEKER, Atlas Ichth. Muræn. **4** (1864) 48, pl. 47, fig. 5; GÜNTHER, Cat. Fishes Brit. Mus. **8** (1870) 71.
> *Ophichthus grandoculis* JORDAN and RICHARDSON, Bull. U. S. Bur. Fisheries 27 (1907) (1908) 238.

Depth 27.2, head 9.5 in total length and 2.6 in trunk; head and trunk together equal 62 per cent of tail, which is in turn 61.8 per cent of total length; eyes moderately large, their upper margin flush with profile, 9.5 in head and 1.5 in snout, the latter 6.1 in head; mouth extends well behind eyes, its gape 3.7 in head; teeth subulate to rounded, in one row in jaws except about symphysis of mandibles, where they are slightly two rowed; four rather bluntly pointed teeth on premaxillary and a double row on vomer, anterior ones largest; pectorals 2.6 in head; height of dorsal about one-third the depth of body and it begins just before middle of the reflexed pectoral.

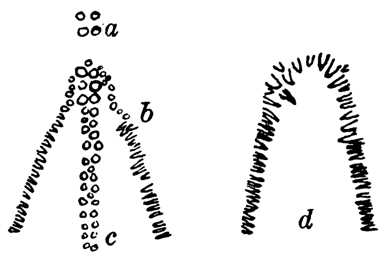

FIG. 5. *Ophichthus grandoculis* (Cantor), dentition; *a*, intermaxillary plate; *b*, maxillaries; *c*, vomer; *d*, mandibles. × 3.

Body everywhere very finely punctulated with minute dusky specks, over a pale whitish yellow ground color; on top of head

and along dorsal line these specks coalesce or are so close together that the animal is nearly uniform dusky olive, becoming paler below the lateral line and light colored along underside; fins grayish, dorsal and anal edged with black, pectorals posteriorly dusky.

Here described from a female specimen nearly ready to spawn, collected at Jordan, Guimaras, in June, 1922, by Mr. H. R. Montalban. Its dimensions are as follows: Length, 409 millimeters; head, 43; trunk, 113; tail, 253; eye, 4.5.

This rare species was described by Cantor from specimens obtained at Pinang and has not been recorded by any other authors except Jordan and Richardson, who determined as *Ophichthus grandoculis* a specimen obtained by Mr. R. C. McGregor in Manila.

Ophichthus apicalis (Bennett).

Ophisurus apicalis BENNETT, Cat. Zool. Spec. in Memoir, Life of Raffles (1830) 692.

Ophichthys bangko BLEEKER, Atlas Ichth. Muræn. 4 (1864) 51, pl. 14, fig. 1.

Ophichthys diepenhorsti BLEEKER, Atlas Ichth. Muræn. 4 (1864) 52, pl. 15, fig. 4.

Ophichthys apicalis GÜNTHER, Cat. Fishes Brit. Mus. 8 (1870) 70; WEBER and BEAUFORT, Fishes Indo-Austr. Arch. 3 (1916) 305, fig. 145.

Depth 27 to 36.6 and head 8.5 to 10.4 in total length; head 2.4 to 2.7 in trunk; head and trunk together 1.4 to 1.71 in tail; eye $8\frac{3}{4}$ to $12\frac{2}{3}$ in head, $1\frac{1}{2}$ to $2\frac{2}{3}$ in the projecting, bluntly pointed snout; mouth extending from just behind eye to a trifle more than diameter of eye behind it and contained from 3.3 to 3.6 in head; pectorals 2.55 to $3\frac{1}{3}$ in head; dorsal low, its origin approximately above the middle or last part of pectorals in my specimens, but according to authors "commencing somewhat before or behind end of pectorals;" dorsal and anal fins expanded or higher near tip of tail; teeth pointed, conical, those of jaws in one row ("they may form anteriorly or near the middle an irregular double series," Weber and Beaufort); in two of my specimens the anterior teeth of mandible are in two rows; on the forward half of vomer the teeth are stouter and two rowed, usually irregularly arranged; posterior half with one row; No. 1449, Bureau of Science collection, has the vomerine teeth in three rows, becoming reduced to two rows posteriorly and the last few teeth uniserial; teeth on intermaxillary plate variable, four to six in my specimens, arranged irregularly or in pairs; lateral line prominent, the wide-spaced pores as in Bleeker's

figure of *Ophichthys diepenhorsti* but beginning on top of head, halfway between gill openings and tip of snout.

The ground color in life is light gray, varying to whitish on belly and throat; darkened to dark gray or dusky above the lateral line by innumerable minute dots which are absent only on belly and throat.

Color in alcohol pale brownish gray to dark brown, paler brown to whitish below, especially on belly and throat; thickly sprinkled, especially above, with minute dark brown dots, which are absent on belly and underside of head; fins dusky to colorless in my material, but black or with a black margin according to authors.

This inconspicuous little eel is easily recognized by its dentition and the relative proportions of head and tail. The body is plump, the transverse diameter nearly or quite equal to the depth. The head is small, the lower jaw weak, much shorter than the upper one.

As usual in this group the throat is longitudinally striate or pleated and much inflated.

I have examined five living specimens from the Manila market, and numerous alcoholic specimens from Malabon, Manila, Mindoro, Dumaguete, Cagayan de Misamis, and Davao, Mindanao. They vary in length from 181 to 345 millimeters.

This species attains a length of 430 millimeters; it occurs in seas and bays throughout the East Indies from Singapore to Celebes, and northward to the coast of China.

Ophichthus macrochir (Bleeker).

Ophisurus macrochir BLEEKER, Verh. Bat. Gen. **25** (1852) Muræn. 26.
Ophichthys macrochir BLEEKER, Atlas Ichth. Muræn. **4** (1864) 54, pl. 20, fig. 1; GÜNTHER, Cat. Fishes Brit. Mus. **8** (1870) 72; WEBER and BEAUFORT, Fishes Indo-Austr. Arch. **3** (1916) 306.

Depth 42 to 55.5, head from 14.5 to 17.7 in total length; head 4 to 5.3 in trunk; head and trunk 1.7 to about twice in tail; eye 10.4 to 13 in head, and about twice in snout, which is 5 to 6 in head; cleft of mouth extending just behind eye, 2.9 to 3.6 in head; pectorals 3 to 4.5 in head; origin of dorsal opposite last quarter of pectorals or farther behind, in my smaller specimen about the length of pectoral behind its tip; vertical fins low, the anal the higher, less than one-half depth.

Teeth very small, pointed, all uniserial except on anterior portion of vomer where they are in two rows and strongest; intermaxillary teeth said to be in about three pairs, but in my material there are but two teeth in a row in one specimen

while in the other they are broken out but were originally in a single row also.

This is a delicate and slender eel with small head and weak jaws, snout convex and rather bluntly pointed; posterior nostrils partly below front margin of eyes; lateral line prominent, the pores beginning on neck; tail deeper than trunk.

Color uniform brown, paler on belly, much paler on throat; fins pale yellow brown, or else hyaline from the action of the presèrvative.

No. 130, Bureau of Science collection, from Cavite, has the following dimensions: Length, 444 millimeters; depth, 8; head, 26; trunk, 138; tail, 280; eye, 2.5; snout, about 5; gape, nearly 9; pectoral, 8.

I have also placed here a specimen from the University of the Philippines, supposed to have been collected at Cavite likewise, which has a single instead of a double row of teeth on the vomer, but which otherwise agrees with No. 130; its dimensions are as follows: Length, 284 millimeters; head, 18; trunk, 84; tail, 182; depth, 5.25.

My material is slenderer than the specimens described by Bleeker and others; they state the depth to be from 42 to 48 times in the length. As elsewhere noted, the teeth of the intermaxillary plate are exceedingly variable as well as subject to numerous accidents, while the teeth occurring in two or more rows are prone to individual variations and irregularities.

Hitherto known only from Java and Sumatra; it lives in the sea and in brackish water.

Ophichthus manilensis sp. nov. Plate 5.

Depth 51.69 to 54.2, head 17.68 to 16.6 in length; head 5 to 5.4 in trunk, the latter a trifle more than twice in tail; head and trunk together 1.73 to 1.75 in tail, which is 0.63 of total length. Eyes full, somewhat elliptical, 2 or 2.4 times in snout and 12.4 to 15.2 in head; snout 6.2 to 6.3 in head, its tip rounded; mouth large, extending beyond eyes, 3.1 to 3.4 in head; pectorals large and rounded in life, 3.4 to 3.87 in head; origin of dorsal over the beginning of the last fourth of pectoral.

An elongate and very slender eel but with the body full and rounded, the tail bulkier and deeper than the trunk, its transverse diameter equal to its depth; dorsal and anal fins low, less than half the depth of body; lateral line starting on nape; posterior nostrils just forward of a vertical line from eyes. Maxillary teeth in one row or in two rows on posterior part; teeth of lower jaw in one row; teeth on vomer in two rows or with

a third poorly developed inner row on anterior half; intermaxillary plate with three larger teeth in a single row, the first one the largest.

Skin on dorsal surface between lateral line and dorsal fin curiously folded and reticulated by longitudinal wrinkles; a double row of four pairs of pores on top of snout, curving around eyes and joining another row on upper lip above rictus; a row of pores also on each side of lower jaw.

Color in life greenish brown above, pale yellow to gray brown beneath, everywhere thickly sprinkled with minute dark specks; iris of eyes golden, pupil black.

Color in alcohol uniform brown, paler on belly, throat grayish brown; fins heavily sprinkled with minute dark dots so as to appear uniform grayish brown.

The type, Bureau of Science collection No. 9477, is from a collection made at Cavite in 1907. The cotype, No. 9488, I obtained alive in the Tondo market, Manila; it was brought from some bañgos fishpond in Bulacan, along with a large quantity of *Synbranchus bengalensis.*

Measurements of Ophichthus manilensis.

	No. 9477.	No. 9488.		No. 9477.	No. 9488.
	mm.	*mm.*		*mm.*	*mm.*
Length	672	515	Eye	2.5	2.5
Depth	13	9.5	Snout	6	5
Head	38	31	Gape	12	9
Trunk	206	157	Pectoral	11	8
Tail	428	327			

I place here tentatively a small delicate eel from Malabon, Bureau of Science collection No. 837, until additional material is available, as I do not wish to multiply new species unduly. As yet we know so little of the differences in ophichthyoid eels due to age, and the intermaxillary teeth are so readily broken, that it is unsafe to give new names where we have any reason to believe that two forms might possibly belong together.

Depth 55, head 15.7 in length; head 4.89 in trunk; head and trunk together $1\frac{2}{3}$ in tail; eye 2.5 in snout, 14 in head; snout acute, pointed, 5.6 in head, pectoral 4; cleft of mouth extends beyond eye and is 2.8 in head; maxillary teeth in one row anteriorly, in two rows posteriorly; those on vomer in two rows anteriorly, and in one row at back end; teeth in mandibles are in one row except that those on front half of left side are in two rows; there is a row of two teeth on intermaxillary plate.

Tail deeper than body; origin of dorsal fin behind pectoral; posterior nostrils before eyes; lateral line prominent, the pores continuous from nape.

Color uniform blackish brown above, paler on sides, becoming slaty brown on belly and throat; fins slightly paler but uniform in color with body.

This specimen has the following dimensions: Length, 440 millimeters; depth, 8; head, 28; trunk, 137; tail, 275; eye, 2; snout, 5; gape, 10; pectoral, 7.

A specimen from Mindoro, in the museum of the University of Santo Tomas, apparently belongs here also. The skin of the whole body, excepting only the head, is roughened by an encysted parasite. The vomerine teeth are in three rows anteriorly; the origin of the dorsal is behind the pectorals.

This species is separated from other East Indian members of the genus by marked differences in the relative length and depth and in the dentition.

Ophichthus rutidodermatoides (Bleeker).

Ophisurus rutidodermatoides BLEEKER, Verh. Bat. Gen. 25 (1852) Muræna 31.

Ophichthys rutidodermatoides BLEEKER, Atlas Ichth. Muræn. 4 (1864) pl. 16, fig. 1.

Ophichthys rhytidodermatoides GÜNTHER, Cat. Fishes Brit. Mus. 8 (1870) 62; WEBER and BEAUFORT, Fishes Indo-Austr. Arch 3 (1916) 309, fig. 147.

Depth 46 to more than 50 in total length; head 15 to 16.5 and 4 to nearly 5 in trunk; head and trunk together about one-half of tail (five-ninths in my specimen); eyes very small, elongate, $2\frac{1}{8}$ in snout and $11\frac{1}{3}$ in head; head small, with weak jaws, the lower one particularly so, the long and sharply pointed snout projecting more than half its length beyond mandible; cleft of mouth extending well behind eyes, and contained from less than 3 to 3.5 in head; anterior nostrils in short tubes pointing downward, and behind tip of snout; posterior nostrils below anterior margin of eyes; pectorals from 3 to 3.4 in head; intermaxillary plate with four comparatively large, irregularly placed teeth, the lower jaw not extending to them; all teeth fixed, pointed, those in jaws in two rows except the first few in the maxillaries, which are in one row; teeth on forward part of vomer in two rows, changing to one row posteriorly; general arrangement of teeth as in Weber and Beaufort's figure, but differing somewhat in detail; dorsal and anal low, the latter apparently the higher in my specimen but both so closely appressed as to make their

measurement difficult, not quite half the depth of body; dorsal beginning a little forward of extremity of pectorals; lateral line conspicuous.

Color in alcohol blackish brown, slightly paler below, fins all dark. The spots shown in Bleeker's figure are lacking in my specimen.

Body very elongate and snakelike, rounded, not flattened except at very tip of tail.

I have examined a specimen, No. 3417, Bureau of Science collection, from Davao, Mindanao, having the following dimensions: Length, 560 millimeters; head, 34; trunk, 166; tail, 360; depth, 11; eye, 3; snout, 7; gape, 12.

Heretofore recorded from Java, Pinang, and Ceylon. I have followed Bleeker's spelling and not the alteration made by Günther.

Ophichthus celebicus (Bleeker).

Ophisurus celebicus BLEEKER, Act. Soc. Sci. Indo-Neerl. 1 (1856) Visschen Menado, 70.

Ophisurus broekmeyeri BLEEKER, Act. Soc. Sci. Indo-Neerl. 1 (1856) Visschen Menado, 71.

Ophichthys amboinensis BLEEKER, Ned. Tijdschr. Dierk. 2 (1864–1865) 45, Atlas Ichth. Muræn. 4 (1864) 54, pl. 45, fig. 1.

Ophichthys broekmeyeri BLEEKER, Atlas Ichth. Muræn. 4 (1864) 53, pl. 15, fig. 1.

Ophichthys celebicus BLEEKER, Atlas Ichth. Muræn. 4 (1864) 54, pl. 15, fig. 3; WEBER and BEAUFORT, Fishes Indo-Austr. Arch. 3 (1916) 311.

Depth 30.5 to 36 in length; head $2\frac{1}{3}$ to 2.77 in trunk, 9 to 9.83 in length; head and trunk together from 0.62 to about 0.75 of tail, which is nearly two-thirds the total length; eyes moderately large, 11 to 12.4 in head and twice in snout, which is about 6 in head; pectorals about 3 in head (2.58 in my specimen); posterior nostrils in advance of eyes, the opening beneath their forward margin. Maxillary teeth irregularly two rowed, those in lower jaw in one row, except at tip where they are in two rows for a short distance; vomerine teeth in two rows, becoming irregularly three rowed posteriorly; teeth on intermaxillary plate in two or three pairs; teeth not uniform in size,

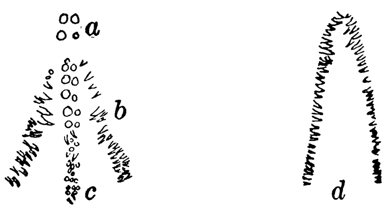

FIG. 6. *Ophichthus celebicus* (Bleeker), dentition; *a*, intermaxillary plate; *b*, maxillaries; *c*, vomer; *d*, mandibles. × 3.

those on forward end of vomer largest, with their points more or less curved backward.

A small eel with pointed snout and rounded body, only posterior portion of tail being laterally compressed; origin of dorsal over middle or posterior third of pectoral; vertical fins low, less than half the depth of body, ending a little more than the diameter of eye from tip of tail.

Color in alcohol dark purplish brown, paler on underside of head and forward half of belly; everywhere thickly sprinkled with minute dark red-brown dots, these excessively abundant on dorsal surface; fins speckled like body.

A specimen from Malabon, Bureau of Science collection No. 835, has the following dimensions: Length, 305 millimeters; head, 31; trunk, 86; tail, 188; eye, 2.5; snout, 5; gape, 8; pectoral, 12.

This eel has been previously recorded only from Celebes, Amboina, and Nias Islands; it attains a length of 486 millimeters.

Genus **LAMNOSTOMA** Kaup

Lamnostoma KAUP, Uebersicht der Aale, Arch. Naturg. 22 (1856) 49; Cat. Apod. Fishes Brit. Mus. (1856) 23.

Slender, cylindrical, small eels, with very sharp-pointed and much-projecting snout so that the mouth is far back, as in certain sharks; the anterior nostrils are on the flat undersurface of snout, near its tip, and have a broad, ear-shaped margin, broadest posteriorly and with a small cutaneous tag or flap on middle of inner edge. The gill openings are ventral, close together, small oblique slits curving outward posteriorly, and with an outer and much longer fold of the gill opening duplicating them and extending much farther anteriorly. Dorsal and anal very low, the former beginning a short distance back of gill openings; no pectorals. Anus a little before or behind the middle of length. Teeth uniserial.

A small genus of the southern and southeastern Asiatic waters. Closely related to *Sphagebranchus*, from which it differs in having fins, and in having nostrils of dissimilar character.

Lamnostoma orientalis (McClelland). Plate 6, fig. 1.

Dalophis orientalis MCCLELLAND, Calcutta Journ. Nat. Hist. 5 (1845) 213.

Lamnostoma pictum KAUP, Cat. Apod. Fishes Brit. Mus. (1856) 23, fig. 11.

Sphagebranchus orientalis KNER, Novara Fische (1865–67) 380; WEBER and BEAUFORT, Fishes Indo-Austr. Arch. 3 (1916) 321, fig. 154, *b*.

Ophichthys orientalis GÜNTHER, Cat. Fishes Brit. Mus. 8 (1870) 87; DAY, Fishes of India (1878–88) 665, pl. 171, fig. 1.

Depth 30.55 to 35.5 in length, head 7.88 to a trifle more than 8, and 2.88 to 3.1 in trunk; tail about same length as, or a little more or less than, head and trunk together; eyes small, 14.4 to 20 in head and 3 to 3.4 in snout, which is very sharp pointed and much exceeds mouth; measured from tip of snout to angle of mouth, the gape is contained from 3 to 3.5 in head; anterior nostrils on the flat undersurface of snout near tip, the margin wrinkled and earlike, longest posteriorly; posterior nostrils in upper lip, looking downward, before eyes, just behind a pendulous papilla; origin of dorsal very close to gill openings, the distance between being one-seventh to one-ninth the length of head; the vertical fins are low but plainly evident and are interrupted posteriorly by an interspace where they are reduced to a fold, becoming expanded again and terminating near tip of tail, as shown in the figure; teeth in one row in jaws and on vomer, very small, acute, and nearly uniform in size, those of lower jaw a little stouter and longer; three or four pairs of stouter teeth on intermaxillary plate, almost concealed by the overlying flaps of upper lip; gill openings ventral, oblique, close together, curved and converging anteriorly; the anterior gill membranes form a longer duplication just outside of and extending farther forward than the gill openings; a row of paired pores on snout, extending around eyes, and a less conspicuous row on lower jaw; lateral line originating on occiput.

Color of alcoholic specimens uniform dark brown above, becoming paler on sides and yellowish brown beneath; upper part of body speckled with innumerable minute dark dots; chin and throat much paler; a series of round whitish spots across occiput and a short whitish bar composed of similar spots directed forward along each side toward eyes; whitish around eyes and along upper lips.

A small eel, the body as broad as deep, very abundant at Madras and along the coasts of India and Ceylon; also known from Madagascar and a single specimen from British New Guinea. The lower jaw is noticeably weak, the contour of snout and jaws very similar to that of the Cirrhimurænidæ.

Here described from three typical specimens in the collection of the College of Agriculture at Los Baños. Their dimensions are given in the table.

Measurements of three specimens of Lamnostoma orientalis

Length.	Depth.	Head.	Trunk.	Tail.
mm.	*mm.*	*mm.*	*mm.*	*mm.*
275	9	34	104	137
280	9	35	110	145
142	4	18	52	72

Genus CÆCULA Vahl

Cæcula VAHL, Skrivt. Naturh. Selsk. Kjobenhavn 3 (1794) 2, 149; JORDAN and DAVIS, Apodal Fishes America and Europe, Report U. S. Comm. Fish. 16 (1888) (1892) 622.

A small genus related to *Sphagebranchus* from which it is separated by the possession of more or less developed fins, and the presence of enlarged teeth on the vomer, and from *Lamnostoma* by the absence of false gill openings made by outer duplications of the true gill openings, and the position of the gill slits which are lateral or only partially ventral. Gill slits vertical or nearly so, the interspace but little, if any, narrower than their length. Body small, rounded, with rather small head and weak jaws; dorsal fin inserted behind gill openings.

Species not numerous, one in the Mediterranean, others Asiatic.

Key to the Philippine species of Cæcula.

a^1. Depth contained 25 to 30 times in length .... C. mindora.
a^2. Depth contained 18 times in length .... C. taylori.

Cæcula mindora Jordan and Richardson.

Cæcula mindora JORDAN and RICHARDSON, Bull. U. S. Bur. Fisheries 27 (1907) (1908) 239, fig. 4.

Sphagebranchus mindora WEBER and BEAUFORT, Fishes Indo-Austr. Arch. 3 (1916) 322.

Depth 25 to 30 in length, head 7.4 to 7.7, and 2.6 to 2.8 in trunk; tail a little longer than head and trunk together; eyes very small, 17 to 25 in head, about 3.5 in the slender, pointed snout, which is about 7 in head; mouth very wide, 2.5 in head and extending far beyond eyes which are at the end of the first third of gape; the distance between origin of dorsal and gill openings is one-fourth the length of head; vertical fins moderately developed; teeth small, sharp, recurved, in one row;

those on vomer much larger, six to ten in number; intermaxillary plate with three to five large stout teeth in a transverse series, separated from the rest by a wide shallow cross notch into which tip of mandible fits; gill openings lateral, vertical or nearly so, separated by an interspace of their own length.

Color above lateral line uniformly finely punctulated dark brown or grayish brown; lower half yellow or pale, almost a sharp line separating upper from lower color on tail; scattered punctulations extending a short distance below lateral line on trunk; top and tip of snout blue-black; under jaw specked and splashed with bluish black; lateral line with a series of small, more or less stellate whitish spots about the size of eye, or pores in round yellow spots; pores on head in smaller spots which form a transverse band on vertex.

This eel reaches a length of nearly 400 millimeters. It is known only from a specimen from Mindoro Island, and one from Waigeu Island, which was caught above the mouth of a river, in fresh water.

Cæcula taylori sp. nov. Plate 6, fig. 2.

Depth 18.2 in length, head 8.86, and 3 in trunk; tail a little longer than head and trunk together, their length being 82.2 per cent of that of tail; the small protuberant eyes in advance of middle of gape and 1.51 in snout and 14.8 in head; gape wide and 3.08 in head; the distance between the origin of dorsal and a vertical drawn from dorsal to gill openings is contained 9.25 times in head; vertical fins very low, height of dorsal more than 7 in depth; ventral higher than dorsal and twice as high anteriorly as posteriorly; its origin is separated from anal opening by a broad interspace; dorsal and anal end opposite each other, close to tip of tail; vertical gill openings separated by an interspace equal to their length; teeth small, sharp, recurved, in single rows, about thirty of uniform size in each maxilla and about twenty-two on each side in lower jaw; the first two pairs in mandible much stouter than the others; three rather small teeth on intermaxillary plate, their arrangement shown in the figure; a row of five widely spaced teeth on vomer,

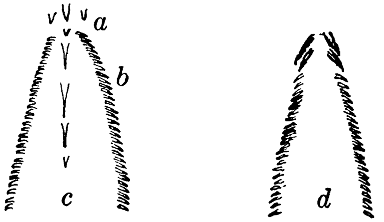

FIG. 7. *Cæcula taylori* sp. nov., dentition; *a*, intermaxillary plate; *b*, maxillaries; *c*, vomer; *d*, mandibles. × 4.

the first three much larger than any of the other teeth, the last one very small.

A small, heavy-bodied insignificant eel with weak, narrow, sharp-pointed jaws and rounded tail that tapers to a sharp point likewise. Ground color pale to whitish, apparently in life clear light yellow; dorsal region dark olivaceous brown, made so by the coalescence of innumerable dots which extend down the sides below the conspicuous lateral line and over lower jaw.

Here described from the type and only specimen, collected in January, 1922, in Cabatoan River near Iba, Zambales, by Mr. H. R. Montalban. It is close to *Cæcula mindora* of Jordan and Richardson, and to *Cæcula macrodon* (Bleeker), but differs from them both in bodily proportions and dentition.

Its dimensions are as follows: Length, 164 millimeters; depth, 9; head, 18.5; trunk, 55.5; tail, 90; eye, 1.25; gape, 6.

I take pleasure in naming this species for Mr. E. H. Taylor, student of Philippine reptiles and amphibia.

MORINGUIDÆ

Body slender and more or less cylindrical, tail much shorter than rest of body. Pectorals small, vestigial, or altogether lacking; dorsal and anal fins small and low, confined to tail, and often reduced to a small fin around tip of tail. Head small, usually depressed, with posterior nostrils in front of eyes, which are small and usually covered with skin; mouth small, weak, with small, uniserial teeth, lower jaw projecting; gill openings usually narrow, inferior; heart located far behind gills.

Small eels of the tropical seas of both hemispheres, the genera closely related and the species often difficult to distinguish. The family is easily recognized by its remarkably wormlike appearance, in connection with its weak head, elongated trunk, and very short tail.

This small group of peculiar eels is probably related most nearly to the morays, but its relationships are not certain.

Key to Philippine genera of the Moringuidæ.

a^1. Dorsal and anal higher and with visible rays anteriorly and posteriorly; lower, or a mere fold of skin in the middle .... **Moringua.**

a^2. Vertical fins reduced to a low fold and developed only at tip of tail. **Aphthalmichthys.**

Genus MORINGUA Gray

Moringua J. E. GRAY, The Zool. Misc. (1831) 9.
Rataboura J. E. GRAY, Ill. Ind. Zool. (1831) 95.

Body wormlike, depth 30 to 60 in length, dorsal and anal well developed around tail, then reduced to a low fold or ridge of skin; farther forward again developed so that they are as high as or higher than on tail, with visibly developed rays; pectorals may be vestigial, but are usually well developed though small; teeth acute, in one row on jaws, uniserial or irregularly two rowed on vomer.

This genus is easily distinguished by the peculiar character of the dorsal and anal fins, each being divided into two parts, separated by a considerable interspace.

Key to Philippine species of Moringua.

a^1. Intermaxillaries with two rows of teeth; depth less than 35 in length. **M. robusta.**

a^2. Intermaxillaries with one row of teeth; depth over 50 in length; distance of anal from anus four-fifths the length of head............ **M. cagayana.**

Moringua robusta sp. nov. Plate 7.

Depth 3.5 in head and 34.4 in total length, head 5.16 in trunk and 9.77 in whole length; tail shorter than head and trunk together, being contained 1.4 in trunk alone and is almost 37 per cent of total length; eyes small, 26.8 in head and 2.4 in the small, rather sharp snout which is $11\frac{1}{6}$ in head; mouth extending beyond eye, 6.7 times in head, lower jaw very slightly projecting; distance of origin of anal from anus 4.46 in head; origin of dorsal behind that of anal, the difference being a trifle more than 2.3 in head, while distance from anus to dorsal is a very little more than 1.5 in head, being almost exactly two-thirds the length of head; pectorals, though short, are broad and well developed, $8\frac{3}{8}$ in head, with nine rays, base equal in breadth to length of snout; teeth all small, pointed, recurved; maxillary teeth tiny, eighteen to twenty in a single row; nine small teeth in outer row on intermaxillary, with two or three slightly larger ones in inner row on each side; seven or eight teeth on vomer; about twenty small teeth on each side of lower jaw.

This eel is noticeable for its stout body, which is slightly broader than its greatest depth, and for its long head, which terminates in noticeably small, weak snout and jaws; dorsal and anal fins originate as a mere fold but soon become comparatively

well developed with plainly visible rays, their height a little less than one-third that of tail beneath; they are reduced to folds of skin farther back but become much larger, a little less than two-thirds the length of head from tip of tail, and unite with caudal to form a somewhat spatulate fin; posterior nostrils in front of middle of eyes and very close to them; both anterior and posterior nostrils with distinct, whitish, slightly elevated rims; pectorals immediately behind and somewhat higher than gill openings.

Color dark brown above, light brown below, throat and belly paler to grayish brown; the terminal dorso-caudal-anal fin very dark brown with paler margin.

This eel is close to *Aphthalmichthys macrocephalus,* and to *Moringua floresiana,* but differs markedly from the first in the development of the vertical fins and is quite unlike Bleeker's figure; the dentition is different from that of either of the above-named species, while its proportions are altogether different from those of *M. floresiana.*

Here described from the type and only specimen, Bureau of Science collection No. 9664, from Dumaguete, Oriental Negros. Its dimensions are as follows: Length, 655 millimeters; head, 67; trunk, 346; tail, 242; depth, 19; breadth, 20; eye, 2.5; gape, 10; snout, 6; pectoral, 8.

This species is distinguished from *Moringua microchir* Bleeker by its greater relative bulkiness, longer tail, different position of dorsal and anal, and altogether different dentition.

Moringua cagayana Seale. Plate 8.

Moringua cagayana SEALE, Philip. Journ. Sci. § A 4 (1909) 493.

Depth about 4 in head and 51.3 in total length; head 7.75 in trunk and 13.1 in total length; trunk longer than head and tail together, being more than 0.59 of total; tail almost exactly one-third of total length; eyes small, 18.4 in head and twice in snout; cleft of mouth extends an eye diameter beyond eye and is 4.7 in head; pectorals approximately equal to distance from tip of snout to rear margin of eye. Origin of anal about four-fifths the length of head behind anus; origin of dorsal still farther back, its distance from anus being equal to that from tip of snout to tip of pectorals.

A single row of fragile, sharp-pointed, recurved teeth in each jaw and five pairs of larger teeth on intermaxillary plate; nine teeth on vomer, arranged in an irregular double row as shown in the figure.

A greatly elongated and slender eel with a long head, projecting lower jaw, and large and baggy buccal cavity; tubules to anterior nostrils very short, forming covers to nostrils, the openings minute; posterior nostrils much larger, open, each with a small flap at the forward margin; dorsal and anal fins high and well developed near their origin and for a distance about equal to that from tip of snout to tip of pectorals; then follows an interspace of greater extent, the fins reappearing near tip of tail and uniting with caudal fin to form a broad, paddle-shaped organ.

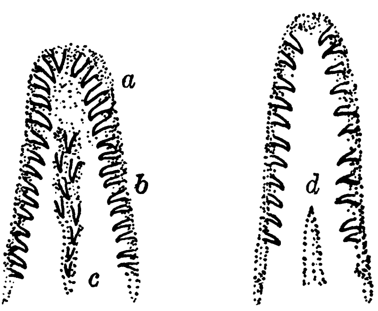

FIG. 8. *Moringua cagayana* Seale, dentition; *a*, intermaxillaries; *b*, maxillaries; *c*, vomer; *d*, mandibles. × 5.

Color in alcohol brown, with a very dark brown line along middle of back; last half of tail blackish brown as are the dorsal and anal fins; pectorals hyaline; body everywhere punctulate with minute dark dots.

The type and only specimen, Bureau of Science collection No. 1621, was caught in the sea near Cagayan, Mindanao, September 13, 1907, by Mr. Alvin Seale. It is a female, approximately 616 millimeters in length, with the body wall distended to paper thinness by the mass of eggs evidently about ready for extrusion, and giving a yellow color to the distorted abdomen. In common with many other fishes, the ovaries in this species extend much farther posteriorly than the anal opening; beginning very far forward, the ovaries are approximately 400 millimeters long while the trunk, from gill opening to anus, is only about 364 millimeters long.

Owing to the softness and the distortion of the abdomen, measurements can only be approximate, but the characters are sufficiently defined to show this to be a unique species.

Genus APHTHALMICHTHYS Kaup

Aphthalmichthys KAUP, Arch. Naturg. 22 (1856) 68; Cat. Apod. Fishes Brit. Mus. (1856) 105.

Body scaleless, wormlike, its greatest depth from 35 to 100 in length. Dorsal and anal fins rudimentary, inconspicuous, threadlike folds, but little developed except around tip of tail; pectorals wanting or vestigial and barely perceptible; eyes rudimentary and more or less covered by thick skin; lower jaw

equal to or longer than upper jaw; teeth weak, pointed, one rowed, on palatines, nasal, vomer, and intermaxillaries; tail much shorter than body; heart placed far behind gills.

Small and usually very slender eels, noticeable for the slight development of the fins and the very short tail. They are found buried in mud, sand, or gravel, in salt or brackish water on reefs along the coast or in river mouths, and they often enter fresh-water streams. They are abundant in the East Indies and are distributed from India to Hawaii and the South Sea Islands, and from Japan to the northern coast of Australia.

These insignificant eels astonishingly resemble certain worms; the species are difficult to distinguish, the characters altering greatly with age.

Key to the Philippine species of Aphthalmichthys.

a^1. Head less than 10 in length.
- b^1. Head 8.5 to 9.9, depth 32 to 43 in length .... **A. macrocephalus.**
- b^2. Head 8.92, depth 28⅓ in length .... **A. lumbricoideus.**

a^2. Head more than 10 in length.
- c^1. Head 10 to 13.3, depth 35 to 47 in length .... **A. abbreviatus.**
- c^2. Head 14 to 22, depth 55 to 95 in length .... **A. javanicus.**

Aphthalmichthys macrocephalus Bleeker. Plate 9, fig. 2.

Aphthalmichthys macrocephalus BLEEKER, Ned. Tijdschr. Dierk. 1 (1863) 165; Atlas Ichth. Muræn. 4 (1864) 17, pl. 3, fig. 2; PETERS, Monatsber. Akad. Wiss. Berlin (1868) (1869) 275.

Moringua macrocephala JORDAN and SEALE, Bull. U. S. Bur. Fisheries 25 (1905) (1906) 195; WEBER and BEAUFORT, Fishes Indo-Austr. Arch. 3 (1916) 341.

Depth 32 to 43 in length, head 7.7 to 9.9, and 4.23 to 5.8 in trunk (4, Jordan and Seale); tail 2.12 to 2.18 in head and trunk together in my specimens (1.7 to 2.3, Weber and Beaufort); the minute eyes 17.3 to 22 in head and 2 to 2.5 in snout; mouth relatively large, lower jaw projecting as in nearly all Moringuidæ, gape 4 to 4.72 in head and extending well beyond eyes; teeth conical, sharp, pointing backward; six to eight on each maxillary, with about eight stouter teeth on intermaxillary plate; four to five small teeth in a single row on vomer, the anterior tooth largest; ten or twelve teeth on each side of lower jaw, the anterior ones largest.

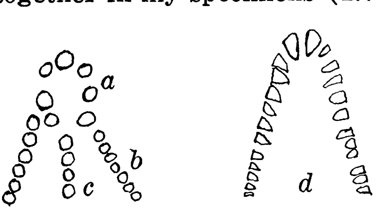

FIG. 9. *Aphthalmichthys macrocephalus* Bleeker, dentition; *a*, intermaxillary plate; *b*, maxillaries; *c*, vomer; *d*, mandibles. × 4.

A robust, wormlike eel, strongly resembling the giant Philippine species of earthworms. Pectorals may be altogether absent or may be present but minute, their length about equaling the diameter of an eye; vertical fins mere seamlike folds of skin, only developed at the end of the tail where they join with the caudal to form a short truncate fin; the distance between anus and origin of anal fin is 1.5 to 1.9 in head; origin of dorsal may be opposite or behind origin of anal; in the latter case the difference between the origin of the two fins is contained 5 to 10 in head. Jordan and Seale state the color in life of a specimen obtained at Pago Pago, Samoa, to be nearly uniform light pinkish brown; the head very clear translucent rosy red; the caudal more orange.

The color in alcohol is dull leaden to brownish above; paler beneath, varying from bluish to yellowish or whitish.

I have examined four excellent specimens, obtained at Alaminos, Pangasinan, by Mr. Eugenio Fénix. They vary in length from 200 to 385 millimeters. In color and general habit of body they contrast strongly with the *Ascaris*-like species, *abbreviatus* and *javanicus*. Another specimen, obtained by Mr. Montalban at Iba, Zambales, is 350 millimeters long, and in life was pinkish brown.

Peters's specimen was collected by Jagor at Legaspi, Albay. This little-known eel attains a length of 700 millimeters and is found from the shores of British India to Samoa. Like its congeners it is a shore dweller, living in the mud around the mouths of streams.

Since the above was printed I have received 5 specimens, from 51 to 138 millimeters in length, from Mr. Angel Villanueva, who collected them at Luboc beach, Lapaz, Iloilo Province, Panay.

Aphthalmichthys lumbricoideus (Richardson).

> *Moringua lumbricoidea* RICHARDSON, Voyage Sulphur, Ichth. (1844) 113, pl. 56, figs. 7–11; GÜNTHER, Cat. Fishes Brit. Mus. **8** (1870) 91, pro parte; JORDAN and SEALE, Proc. U. S. Nat. Mus. **28** (1905) 773; JORDAN and SEALE, Bull. U. S. Bur. Fisheries **26** (1906) (1907) 7.

I have not seen this species, but Jordan and Seale had a specimen from Cavite and two from Negros which they named *Moringua lumbricoidea*. An examination of Richardson's figure shows that his specimen lacked the essential character of *Moringua* as distinguished from *Aphthalmichthys*, while his description of the fins is that of the latter genus. His figure also

shows *lumbricoideus* to have the dorsal and anal fins much better developed than they are in *macrocephalus*.

The following is Richardson's original description:

In *M. lumbricoidea* the gill openings are small, lateral, and on their posterior edge there is a minute fold, which is perhaps the vestige of a pectoral fin. The head is small, conical, with a moderately acute, but not pointed, snout, projecting very slightly beyond the lower jaw. One nostril opens at the inner angle of the eye, and the other near the end of the snout. A series of large pores runs along the snout on each side and across the nape. The throat is plaited and distensible. Teeth acute, short, subulate, inclined backwards, in a single series, on both jaws and along the vomerine line. The lower teeth of *M. linearis* are described as blunt (Gray l. c.). The body is very nearly cylindrical, and retains its thickness equably from the gill opening to some distance beyond the anus.

The rest of the tail tapers slightly, and is a little compressed. The skin is smooth and even throughout, no scales are visible, and no lateral line. The dorsal and anal fins are highest at the end of the tail, where they unite. The anal runs forward to the anus, gradually lowering in height to a mere line. The dorsal cannot be traced so far forward. The thickness of the integument prevents the fine rays of these fins from being readily counted, but at the tip of the tail there are fifteen rays, a little thicker, which may be considered as a caudal. The general color is pale reddish-brown, gradually fading to white towards the belly, and finely sprinkled with darker dots

DIMENSIONS

	Inch.
Tip of snout to end of tail	10.00
Tip of snout to gill-opening	1.12
Tip of snout to anus	6.75

Aphthalmichthys abbreviatus Bleeker.

Aphthalmichthys abbreviatus BLEEKER, Ned. Tijdschr. Dierk. 1 (1863) 163; Atlas Ichth. Muræn. 4 (1864) 17, pl. 1, fig. 1; JORDAN and SNYDER, Proc. U. S. Nat. Mus. 23 (1901) 877.

Moringua abbreviata GÜNTHER, Cat. Fishes Brit. Mus. 8 (1870) 92; JORDAN and SEALE, Proc. U. S. Nat. Mus. 28 (1905) 773; JORDAN and RICHARDSON, Bull. U. S. Bur. Fisheries 27 (1907) (1908) 241; WEBER and BEAUFORT, Fishes Indo-Austr. Arch. 3 (1916) 341.

I refer here nineteen small wormlike eels, having a remarkable resemblance to the parasitic nematodes belonging to the genus *Ascaris*. They were collected at Dumaguete, Oriental Negros, and vary in length from 125 to 195 millimeters, and in depth from less than 3 to about 5 millimeters.

Depth 35 to 47 in length; head 10 to 11.5 in length in my material (to 13.3, Weber and Beaufort) and 6 to 7.5 in trunk; tail 2.8 to 3.2 in length of head and trunk together; distance from anus to origin of anal fold $1\frac{2}{3}$ to $2\frac{5}{6}$ in length of head. The head is longer in these than in those described by authors,

but in all this group older and larger specimens have the trunk longer proportionately.

This species may be distinguished from *Aphthalmichthys javanicus* by its stouter habit of body and by the much shorter distance between the anus and the origin of the fold of skin which represents the anal fin. In other respects the description of *javanicus* might serve for this species.

Found throughout the East Indies, ranging northward to the Riu Kiu Islands, and southeast to the Fiji Islands. Previous Philippine records are from Ticao Island, and from southern Negros.

A shore- and reef-dwelling species, burrowing in mud, sand, and gravel, and entering the mouths of streams.

Aphthalmichthys javanicus Kaup.

Aphthalmichthys javanicus KAUP, Arch. Natur. 22[1] (1856) 68; Cat. Apod. Fishes Brit. Mus. (1856) 105, pl. 14, fig. 71; BLEEKER, Atlas Ichth. Muræn. 4 (1864) 16, pl. 2, fig. 2; JORDAN and SNYDER, Proc. U. S. Nat. Mus. 23 (1901) 877.

Moringua javanica GÜNTHER, Fische d. Südsee 3 (1910) 405; WEBER and BEAUFORT, Fishes Indo-Austr. Arch. 3 (1916) 342, fig. 164.

Body exceedingly wormlike in color and in general appearance; no pectorals; dorsal and anal reduced to mere threadlike folds and only developed, and then but slightly, around the tip of the rather blunt tail; origin of anal about the length of head or a little more from anus; origin of dorsal approximately opposite anal; lateral line prominent, with numerous pores, beginning on occiput or halfway between eyes and gill slits; head small, weak, depressed, lower jaw projecting and relatively much stouter; cleft of mouth extending far behind eyes, which are very small, rudimentary, and covered with thick skin; anterior nostrils with short tubes, the posterior ones immediately in front of eyes, their rims with a flap on anterior side; teeth in a single row, pointed, recurved, the front ones much the larger and stronger.

A specimen from Dumaguete, Oriental Negros, has the following dimensions: Length, 387 millimeters; depth, 6.5; head, 26; trunk, 242; tail, 110; cleft of mouth, 4.5; distance from anus to origin of anal, 31; eye 26 in head.

In a Philippine specimen obtained from the Manila Normal School collection, exact locality unknown, the dimensions are as follows: Length, 333 millimeters; depth, about 6; head, 23; trunk, 215; tail, 92; snout, 3.5; cleft of mouth, 4.5; origin of anal 25 millimeters behind anus; eye minute, about 30 in head.

Depth 55 to 95 in length, head 14 to 22, and 7.5 to 13 in trunk; tail 2.5 to 3.1 in length of head and trunk together; cleft of mouth 4.5 to 5.5 in head.

Color pale, like that of *Ascaris,* to a brownish earthworm hue. Abundant in the East Indies, found in southern Japan, and widely distributed among the South Sea Islands. According to Günther it reaches a length of 3 feet (nearly 1 meter).

Burrowing in sand, gravel, and mud along the seashore, especially near the mouths of fresh-water streams.

MURÆNIDÆ

MORAYS

This group includes large and powerful eels, with cylindrical or more or less compressed and elongate to very elongate body. They are distinguished at once by their thick, leathery, scaleless, often beautifully colored skin, their lack of pectorals, and their small, lateral, widely separated, nearly circular gill openings; the latter in some become nearly horizontal slits. Dorsal and anal fins confluent with anal and usually covered with thick skin; they may be well developed or reduced to a vestige at end of tail. Cleft of mouth extends behind eye; the jaws are usually narrow and often so curved and the mouth so filled with large knifelike or canine teeth that they cannot be closed. Teeth in one or more series in jaws, on intermaxillary plate, and on vomer; they may be granular, molarlike, conical, or compressed, pointed, depressible, and fanglike. Anterior nostrils in a tube near tip of snout; posterior nostrils before or above eye and sometimes with an elevated rim or a short tube.

The skeleton shows the Murænidæ to be a degenerate type, farthest removed from the more typical fishes from which the eels developed. Those without fins are the simplest in structure, but this is a mark of degradation and they are farthest from the primitive stock.

A large family with ten or twelve genera and perhaps a hundred species or more, found in the tropical and subtropical seas of both hemispheres. They abound about coral reefs, and in pools on exposed tide flats where many of the species burrow in the coral sand with startling rapidity when disturbed.

The morays are voracious and quarrelsome fishes and include some of the largest of the eels. Many of the species are very beautiful, with rich variegated colors in bands, stripes, or mottled and spotted. One may see them moving about and

searching every crevice, or more often discover them coiled under rocks from which they strike at passing fish just as a snake does at its prey. When provoked and cornered they are formidable enemies and inflict terrific wounds, sometimes driving a boatload of fishermen overboard.

According to Calmette,[9] some of the Murænidæ are poisonous, being provided with poison fangs and glands.

> The poison apparatus consists of a pouch situated above the membrane of the palate, which may contain one-half c.c. of venom. The teeth are not pierced by a central canal, and the venom flows between them and the mucus membrane of the palate, which forms a sheath.

While the morays are used more or less for food and, in fact, some are highly prized by epicures, they are apt to be oily and rather indigestible, so that the flesh of large old individuals of some of the species is unwholesome when indulged in freely.

The Moros apply the common Malay name, *indong* or *indang,* to all morays; this name is also current among the Visayans, but very large ones are called *panan̄glitan;* in the Visayan dialect of Samar and Leyte they are called *hagman̄g* and in Cebuano Visayan *han̄git,* while at Iloilo they are known as *ogdoc;* other Visayan names are *haoig, taguibós* and *taguibolos;* the Tagalogs use the name *malabanós,* while they distinguish the large and fiercely biting kinds as *payan̄gitan,* a name evidently the same as the Visayan one for similar morays. Such names as *taguibos* are not only very strongly accented on the last syllable but the accentuation is emphasized by being drawled as though the speaker were loth to let go the word.

Key to the Philippine genera of Murænidæ.

a^1. Vertical fins well developed; origin of dorsal on head or immediately behind gill openings.
- b^1. Teeth more or less obtuse, molarlike or granular........................ **Echidna.**
- b^2. None of the teeth molarlike or granular.
  - c^1. Tail 1.5 to 2 times as long as head and trunk together; anterior nostrils in a simple tube........................ **Evenchelys.**
  - c^2. Tail equal to or a little longer or shorter than the rest of body.
    - d^1. Anal always present and unmodified.
      - e^1. Trunk very slender, elongate; depth 40 to 55, head 12 to 17 in length........................ **Pseudechidna.**
      - e^2. Depth less than 30, head less than 12 in length...... **Gymnothorax.**
    - d^2. Anal absent or only a trace at tip of tail........................ **Anarchias.**

a^2. Vertical fins reduced to a rudiment at tip of tail or altogether wanting. **Uropterygius.**

[9] Venoms (1908), English translation.

Genus ECHIDNA Forster

Echidna FORSTER, Icones Ineditae; Bibliotheca Banksiae (1777) 181.

Elongate compressed murænids, with the dorsal profile strongly arched, and with blunt, conical, granular or molarlike teeth, their form, number, and arrangement often changed with age; eyes small, covered by skin; dorsal confluent with anal, both covered by thick skin; gill openings small, in the middle of the height of body.

These morays are found about the shores and reefs of tropical seas, and represent the highest degree of specialization of the group. The genus is well distinguished by its blunt teeth, which indicate that crustaceans and mollusks are the chief food.

Key to the Philippine species of Echidna.

a^1. Tail twice or more than twice in head and trunk; dark brown, with thirty to over one hundred narrow white rings .... **E. zebra.**

a^2. Tail equal to, one-third longer, or a little shorter than head and trunk.

- b^1. Body conspicuously banded or spotted.
  - c^1. Twenty-three to twenty-nine broad dark brown bands on body. **E. polyzona.**
  - c^2. Two rows of large stellate spots on each side; interspaces paler with many fine lines and spots .... **E. nebulosa.**
- b^2. Color uniform dark brown or brown marbled with darker; no conspicuous bands or rows of spots.
  - d^1. Color uniform with a white spot on upper lip and a longer one on lower lip near angle of mouth .... **E. rhodochilus.**
  - d^2. Body marbled; no white blotch at angle of mouth.
    - e^1. Teeth on intermaxillary in a semicircle with two stouter teeth in middle .... **E. delicatula.**
    - e^2. Teeth on intermaxillary in five rows, the inner ones largest. **E. amblyodon.**

Echidna zebra (Shaw).

Gymnothorax zebra SHAW, Nat. Misc. 9 (1797) pl. 322.

Echidna zebra BLEEKER, Atlas Ichth. Muræn. 4 (1864) 81, pl. 27, fig. 1; JORDAN and EVERMANN, Bull. U. S. Fish Comm. 23 (1903) (1905) 106, pl. 20; WEBER and BEAUFORT, Fishes Indo-Austr. Arch. 3 (1916) 345, fig. 168; FOWLER, Proc. Acad. Nat. Sci. Phila. 64 (1912) 27.

The depth is contained $20\frac{1}{3}$ in length; the thick, heavy, short head is contained $10\frac{2}{3}$ in total length, $6\frac{2}{3}$ in trunk, and 3 in tail; the last named is short and strongly compressed posteriorly; its length is not quite 28 per cent of the total length and is contained $2\frac{5}{9}$ in head and trunk; eyes rather large and slightly elliptical, their longest diameter contained 8 in head and fifteen-nineteenths of the short blunt snout, which projects well beyond tip of mandible; lower jaw curved so that the mouth cannot be

closed completely and the gape extends far behind eyes, its length 2.4 times in that of head; the teeth on maxillaries in two short rows and much the smallest, the remaining teeth all being broad, smooth, and granular or molarlike; on vomer is a pear-shaped group of large teeth which is broadly connected with a rounded group of similar teeth on the intermaxillary plate so that the whole roof of mouth is studded with teeth, the central ones being the largest; mandible has three or four irregular rows of teeth, those of inner row being the largest; head deep, compressed, and much swollen on occiput; dorsal and anal fins concealed by the smooth, thick, very tough skin and almost obsolete except near tip of tail; dorsal very low, its height only one-fourth or one-fifth that of trunk.

Color in alcohol dark reddish to chocolate brown, with over seventy narrow white rings, each faintly bordered by a darker or blackish edging; the rings may be divided, fragmentary, or broken up into spots, but most of them are complete.

The above description is that of a fine specimen, 640 millimeters long, obtained at Nasugbu, Batangas, November 25, 1922. Its other dimensions are as follows: Depth, 30 millimeters; head, 60; tail, 180; eye, 7.5; gape, 2.4.

According to Weber and Beaufort the proportions are as follows: "Height 17–21; head 8.6–9.75, 4.8 to about 5.5 in trunk. Tail nearly twice to more than twice in head and trunk. Eye 10–12.5, 1.6 to twice in snout. Snout more or less than 7 in head. Cleft of mouth 2.7 to 3.5 in length of head."

The color in life is dark reddish or purplish brown, with from thirty to more than one hundred narrow white, pale yellowish, or golden rings, each bordered by a darker edging than the general body color.

This is the first authentic record from the Philippines of this handsome, easily recognized, and particularly snaky-looking eel.

As there is apparently no such locality as Muscat Cove in the Philippines, neither the Coast and Geodetic Survey nor the Philippine Census Bureau having any knowledge of such a place, I cannot accept Fowler's record cited above.

This eel reaches a length of 1,250 millimeters or more, and is very widely distributed. It was originally described from a specimen obtained in Sumatra, but is now known from the Red Sea and the east coast of Africa to the Hawaiian Islands and throughout Polynesia.

Echidna polyzona (Richardson).

Muræna polyzona RICHARDSON, Voyage Sulphur, Fishes 3 (1844) 112, pl. 55, figs. 11–14.

Echidna polyzona BLEEKER, Atlas Ichth. Muræn. 4 (1864) 81, pl. 24, fig. 3; JORDAN and RICHARDSON, Bull. U. S. Bur. Fisheries 27 (1907) (1908) 241; WEBER and BEAUFORT, Fishes Indo-Austr. Arch. 3 (1916) 346, fig. 169.

Echidna tritor VAILLANT and SAUVAGE, Rev. et Mag. Zool. III 3 (1875) 287.

Echidna zonata FOWLER, Proc. Acad. Nat. Sci. Phila. (1900) 495, pl. 18, fig. 2; JORDAN and EVERMANN, Bull. U. S. Fish Comm. 23 (1903) (1905) 108, fig. 31.

Echidna zonophaea JORDAN and EVERMANN, Bull. U. S. Fish Comm. 22 (1902) (1904) 167; Bull. U. S. Fish Comm. 23 (1903) (1905) 109, pl. 21.

Echidna leihala JENKINS, Bull. U. S. Fish Comm. 22 (1902) (1904) 428, fig. 9; JORDAN and EVERMANN, Bull. U. S. Fish Comm. 23 (1903) (1905) 109, fig. 32.

Echidna vincta JENKINS, Bull. U. S. Fish Comm. 22 (1902) (1904) 429, fig. 10.

Echidna obscura JENKINS, Bull. U. S. Fish Comm. 22 (1902) (1904) 430, fig. 11; JORDAN and EVERMANN, Bull. U. S. Fish Comm. 23 (1903) (1905) 107, fig. 30.

Echidna psalion JENKINS, Bull. U. S. Fish Comm. 22 (1902) (1904) 431, fig. 12; JORDAN and EVERMANN, Bull. U. S. Fish Comm. 23 (1905) (1907) 106, fig. 29.

The variability of this eel is attested by the numerous names which have been applied to its various color phases by different authors.

Depth in total length 15 to 18, head 6.5 to 8.3; head and trunk equal to or a little shorter or longer than tail; eye 8 to 10 in head and a little more than once to twice in snout; gape 2.5 to 3.2 in head, extending well beyond eye.

Body compressed, the tail strongly so and tapering posteriorly; head narrow, strongly elevated between eyes and gill openings, which are small horizontal slits about the midline of body; lower jaw curved, so that not all teeth touch, this fact concealed by the thick fleshy lips; teeth varying much with age, those on maxillary small, usually in two rows; those on vomer large, close-set molars, increasing in size posteriorly; those on intermaxillary plate form an outer series more or less sharp, inclosing three much larger molar teeth extending down the middle; sometimes the molars are more numerous and form an irregular group; teeth on lower jaw in a double row, which becomes a triple row posteriorly in old specimens, those in outer row somewhat smaller; origin of dorsal before gill openings.

Color variable; normally gray or whitish to yellow or brown, with from twenty-three to twenty-nine broad dark brown bands which are continued on fins, the body color appearing as very narrow pale rings which merge along throat and anterior portion of trunk; the dark bands may be irregular, partial, or they may nearly disappear except on end of tail, when the color appears as reticulations or marblings.

There is a single small specimen, 159 millimeters long, in the Bureau of Science collection, taken at Calapan, Mindoro, and I have examined another one, 165 millimeters long, collected at Nasugbu, Batangas, by students of the College of Agriculture. It has also been recorded from Calayan, by Jordan and Richardson.

A shore and reef inhabitant, reaching a length of 550 millimeters, and occurring from the Red Sea to Formosa, Hawaii, and the Paumotu Archipelago.

Echidna nebulosa (Ahl). Plate 10, fig. 3.

Muræna nebulosa AHL, Dissert de Muræna et Ophichtho **3** (1789) 5, pl. 1, fig. 2.

Muræna ophis RÜPPELL, Atlas Reise Nördl. Afrika (1828) 116, pl. 29, fig. 2.

Muræna variegata RICHARDSON, Voyage Erebus and Terror, Fishes (1844–48) 94, pl. 47, figs. 1–5 and 11–16.

Echidna variegata BLEEKER, Atlas Ichth. Muræn. **4** (1864) 80, pl. 24, fig. 2.

Muræna nebulosa GÜNTHER, Cat. Fishes Brit. Mus. **8** (1870) 130, Fische d. Südsee **3** (1910) 423; DAY, Fishes of India (1878–88) 673, pl. 172, fig. 2.

Echidna nebulosa JENKINS, Bull. U. S. Fish Comm. **22** (1902) (1903) 429; JORDAN and EVERMANN, Bull. U. S. Fish Comm. **23** (1903) (1905) 110, pl. 1; WEBER and BEAUFORT, Fishes Indo-Austr. Arch. **3** (1916) 348, fig. 170.

Depth 16 to 21 in total length; head 9.65 to a trifle more than 10 in total length, and from 3.25 to a little more than 4 in trunk; head and trunk together equal to tail, or the latter may be a little shorter or a little longer than rest of animal; eye 8 to 12.5 in head, and from 1.6 to 2.5 in snout, which is 5 to nearly 6 in head; the wide mouth $2\frac{2}{3}$ to 3.5 in head; origin of dorsal in advance of gill openings; maxillary teeth in one row, very small, bluntly conical or granular; intermaxillary plate with two large blunt teeth in the middle, surrounded by a semicircle of about a dozen similar teeth, some of which are smaller than the two inner ones; vomer with two parallel rows of similar teeth nearly as large, six to ten in number; lower jaw with teeth in two rows in

old specimens, the inner row larger; young individuals have two rows in front part of jaw only; teeth near symphysis larger than the rest; all teeth in young specimens more or less pointed and recurved, and a few such occur in the jaws of older ones.

Color in alcohol more or less yellowish, brownish, or whitish with two rows of large, black, irregular, dendritic or stellate spots, one along back and dorsal fin and one along lower half of body, each spot including one to three white or yellow spots; the spots on lower half often connected by black bands crossing undersurface of body; the spaces between the larger spots thickly sprinkled with fine irregular lines and spots.

I have examined eight specimens; one from Guam, three from Leyte, two from Mindoro, and two from Iba, Zambales.

They range in length from 226 to 440 millimeters. One of those from Leyte is a good example of what often befalls eels, and likewise illustrates their power of regeneration. Its tail is only 31 per cent of the total length and but a trifle more than four-sevenths of the length of the trunk; instead of tapering, at least half of it has evidently been bitten off and healed over, the caudal fin being entirely absent.

This common and handsome eel is said to be a savage biter and is feared by the fishermen in some regions. In the Visayas it is called *hagman* or *hagmang*. It is said to reach a length of 5 feet (about 1.5 meters).

This species was obtained by the Challenger Expedition on reefs near Cebu; it has been recorded by Jordan and Seale from southern Negros, and from Calayan Island, north of Luzon, by Jordan and Richardson.

It occurs from Madagascar and along the east coast of Africa to the Red Sea, eastward to China, the Philippines, on to Guam and Hawaii, south to Australia, and everywhere throughout the South Sea Islands.

Echidna rhodochilus Bleeker. Plate 10, fig. 4.

> *Echidna rhodochilus* BLEEKER, Ned. Tijdschr. Dierk. 1 (1863) 247; Atlas Ichth. Muræn. 4 (1864) 79, pl. 23, fig. 4; WEBER and BEAUFORT, Fishes Indo-Austr. Arch. 3 (1916) 350.

Depth 16 to 19 in total length, head 10 to 11 (8 to 10, according to Weber and Beaufort) and 3.6 to $4\frac{1}{6}$ in trunk (3 to 3.6, Weber and Beaufort); head and trunk together one-sixteenth to three-sixteenths shorter than tail; eye 8.5 to $10\frac{2}{3}$ in head and about 1.8 in the rather short, blunt, and rounded snout, which is 6 or a little less than 6 in head; mouth large, reaching far behind eyes,

$2\frac{1}{2}$ to $2\frac{2}{3}$ in head; two rows of small, sharp-pointed maxillary teeth, thirteen to fifteen in each row, those of inner row the larger; intermaxillary teeth larger, about eighteen in outer row with twelve or thirteen much larger ones forming a group covering the plate; vomer with about fifteen teeth, larger than those of maxillaries and in an irregular single or double row; a single row of ten to fourteen teeth on posterior portion of mandible, with from seven to nine pairs of larger teeth on each side at forward end.

A small snakelike eel of insignificant appearance and reminding one of *Uropterygius concolor*, but distinguishable at a glance from all other morays by the elongate white spot below eye on upper lip and a similar but longer one on lower lip, which extends backward to angle of mouth. Color in other respects uniform dark brown or grayish brown in alcohol. The pores on upper and lower jaws white. Dorsal low, inconspicuous except posteriorly, its origin well behind gill openings.

Here described from a specimen 210 millimeters long, from Masbate, Bureau of Science collection No. 1087, and two specimens sent me by Mr. H. R. Montalban, who obtained them in October, 1921, from a fish trap in the mouth of a river near Iba, Zambales. One is a female 350 millimeters long, ready to spawn, the other a male 320 millimeters long, likewise ready for the reproductive act.

Through the courtesy of the Department of Zoölogy of the College of Agriculture at Los Baños I have obtained, as this goes to press, two more specimens, 185 and 195 millimeters long. They were found in holes in a stump in sea water at Palanas, Lemery, Batangas Province, Luzon, January 5, 1923.

This rare species was described by Bleeker from Buru Island, in the Moluccas, and from Rotti Island, southeast of Timor. Weber and Beaufort have specimens also from Simalur and Karakelang Islands.

Echidna delicatula (Kaup).

Poecilophis delicatulus KAUP, Cat. Apod. Fishes Brit. Mus. (1856) 102.

Echidna delicatula BLEEKER, Atlas Ichth. Muræn. 4 (1864) 78, pl. 23, fig. 3; JORDAN and SEALE, Proc. U. S. Nat. Mus. **28** (1905) 772 (Negros); Bull. U. S. Bur. Fisheries **25** (1905) (1906) 204; WEBER and BEAUFORT, Fishes Indo-Austr. Arch. **3** (1916) 350.

Echidna kishinouyei JORDAN and SNYDER, Proc. U. S. Nat. Mus. **23** (1901) 885, fig. 21.

Echidna trossula JORDAN and SEALE, Bull. U. S. Bur. Fisheries **25** (1905) (1906) 203, fig. 8.

Depth 14.5 to 17.4 in total length, head 7.4 to more than 9, and about 3 in trunk; head and trunk together equal to or somewhat shorter than tail; eye 8 to 10 in head and 1.5 to 2 in snout, which is from 5 to more than 6 in head; mouth large, its gape 2.2 to 3 in head; dorsal begins about three-fourths the length of head from snout and is comparatively high, about one-third the depth of body; anal nearly as high; two rows of teeth on maxillaries, the outer row of about twelve minute teeth, the much shorter inner row of six to eight very much larger sharp teeth; ten to twelve large stout recurved teeth in a row around intermaxillary plate with two still stronger teeth in a row in the middle; vomerine teeth separated from intermaxillary plate, stout, rounded, eight to sixteen in number, in a double or an irregular and partially double row; mandibulary teeth small, about eighteen on each side, with four pairs of much stouter granular teeth forming an inner row near symphysis.

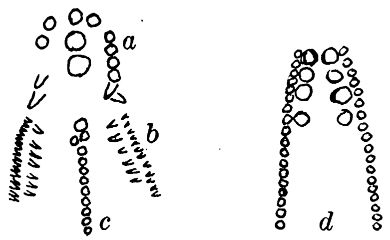

FIG. 10. *Echidna delicatula* (Kaup), dentition; *a*, intermaxillary plate; *b*, maxillaries; *c*, vomer; *d*, mandibles. × 4.

Color dark brown or purplish brown, marbled everywhere with innumerable, fine, irregular, intricate whitish lines, or pale brown to whitish, everywhere marbled with irregular dark brown spots; chin and snout paler.

Here described from two specimens from Puerto Galera, Mindoro, each 160 millimeters in length, and a specimen from Dumaguete, Oriental Negros, having a length of 174 millimeters; one previous Philippine record from southern Negros, by Jordan and Seale.

This beautiful little eel reaches a length of nearly 500 millimeters, and is known from the Riu Kiu to the Samoan Islands.

Echidna amblyodon Bleeker.

Muræna amblyodon BLEEKER, Act. Soc. Sci. Indo-neerl. 1 (1856) 72.
Echidna amblyodon BLEEKER, Atlas Ichth. Muræn. 4 (1864) 79, pl. 22, fig. 1; WEBER and BEAUFORT, Fishes Indo-Austr. Arch. 3 (1916) 351.

Depth 11.4 in total length, head $6\frac{1}{3}$, and 2.5 in trunk; tail 0.9 the length of head and trunk together; eye 7.2 in head, 1.5 in snout, which is 4.8 in head; mouth ample, extending well behind eyes, 2.57 in head; gill openings smaller than eyes; dorsal beginning before gill openings, low anteriorly, but wide

on tail, as is also the anal; five rows of stout teeth on intermaxillary plate, inner rows largest; a double row on maxillaries, inner row much the larger; teeth on vomer not separated from those of intermaxillary plate, first three in a single row, then five pairs, then four in a single row, extending well beyond maxillary teeth; forward half of mandibles with a double row, the remainder with a single row of teeth.

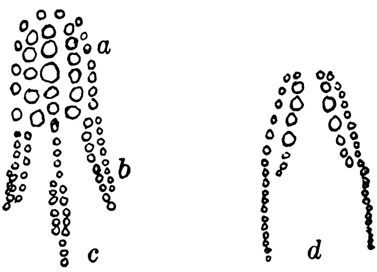

FIG. 11. *Echidna amblyodon* Bleeker, dentition; *a*, intermaxillary plate; *b*, maxillaries; *c*, vomer; *d*, mandibles. × 4.

Color in alcohol uniform brown, with paler throat and belly; small spots of darker brown scattered over the paler parts and faint indications of darker marblings elsewhere, especially posteriorly.

Here described from an unlabeled specimen found in the Bureau of Science collection, probably collected at Puerto Galera, Mindoro. The dimensions are as follows: Length, 114 millimeters; depth, 10; head, 18; trunk, 42; tail, 54.

An insignificant and rather uncommon little eel known from the eastern Sunda Islands, Celebes, the Moluccas, Samoa, and the Marquesas.

Genus **EVENCHELYS** Jordan and Evermann

Evenchelys JORDAN and EVERMANN, Proc. U. S. Nat. Mus. 25 (1903) 327.

Thyrsoidea BLEEKER, Atlas Ichth. Muræn. 4 (1864) 110; WEBER and BEAUFORT, Fishes Indo-Austr. Arch. 3 (1916) 354.

Excessively elongated, slender, and more or less compressed eels, the tail from one and a half times to twice as long as head and trunk; anterior nostrils in simple tubes, without barbels or foliaceous appendages; posterior nostrils on top of head and above forward margin of eye; mouth closing almost completely and reaching far beyond eye, which is nearer tip of snout than corner of mouth; dorsal, anal, and caudal confluent, covered with skin; dorsal inserted in advance of the oblique gill slits which are low down on sides; no pectorals; teeth more or less compressed to needlelike, in two rows in upper jaw and forward part of mandible; one row of small teeth on vomer; intermaxillary plate with a marginal row of small teeth and four long depressible teeth in middle; lateral line conspicuous.

The single species known occurs throughout the Indo-Malayan region from Formosa to British India, Ceylon, Natal, and Queensland.

Evenchelys macrurus (Bleeker).

Muræna macrurus BLEEKER, Nat. Tijdschr. Ned. Ind. 7 (1854) 324.
Thyrsoidea macrurus BLEEKER, Atlas Ichth. Muræn. 4 (1864) 111, pl. 22, fig. 2; WEBER and BEAUFORT, Fishes Indo-Austr. Arch. 3 (1916) 355, fig. 174.
Evenchelys macrurus JORDAN and EVERMANN, Proc. U. S. Nat. Mus. 25 (1903) 327.

Depth 31.5 to 47 in greatest length, head 10 to 14; head and trunk 1.5 to 2 in tail; eye 2.5 to 2.75 in snout, and 17 to 27 in head; mouth large, its gape from 2.4 to 3.4 in head; origin of dorsal from 0.2 to 0.3 the length of head before gill openings, which are oblique, almost horizontal slits with prominent margins; outer row of maxillary teeth very small to medium in size, the posterior ones smallest, twelve to twenty in each jaw; inner row of large needlelike depressible canines nine to twelve in number; intermaxillary plate with an outer row of eight to ten stout fixed teeth, with a central row of three long depressible fangs, the posterior one largest; a short row of small or medium-sized teeth on vomer, varying from three to nine each; each side of mandible with an outer row of sixteen to twenty pointed teeth varying greatly in size but all small, and an inner row of four to seven large depressible canines on each side of forward half; teeth varying much in size and number, apparently because of breakage and regeneration; lateral line conspicuous, the tubules far apart; height of dorsal at anus about 2.5 in body depth at same point.

Color of a fresh specimen, 1,464 millimeters long, uniform brown, becoming darker posteriorly, belly and throat paler to whitish; head ashy brown; dorsal concolorous except near tip of tail where it has a very dark margin, merging into blackish on caudal and contiguous part of anal; the latter fin very low with dark brown margin.

Another fresh specimen, 1 meter long, was uniform dark ashy brown, darker posteriorly, with top of head olive, yellowish around throat, and belly pale ashy; fins as in the previous specimen.

The color in alcohol varies from uniform grayish brown and yellowish to black, the posterior portion usually darkest, the belly and throat paler.

Body very elongate, very slender, and cylindrical or nearly so, being therefore exceedingly serpentine in form. Head low anteriorly, snout often thick, rounded at tip and tumid back to posterior nostrils so that there is a wide deep groove over eyes; mouth large and provided with a formidable array of teeth.

These eels lurk about the small opening to the pound, or innermost inclosure, of the fish corrals, or *baclad,* hiding in holes and seizing fish as they enter the corral. Fresh specimens are usually limp and often shrink very much in preservative. A fresh specimen with a length of 1,453 millimeters contracted 65 millimeters in 50 per cent alcohol and after being transferred to 70 per cent alcohol was found later to have lost over 100 millimeters.

This species breeds in the fall in the Philippines. A specimen taken from Manila Bay, September 1, 1921, having a length of 1,453 millimeters, was full of eggs, while another female with a length of 1,260 millimeters, caught in November, 1921, near Alaminos, Pangasinan Province, was ready to spawn.

I have examined two specimens from Lingayen Gulf, Alaminos, Pangasinan Province, three from Manila Bay, one from Iloilo, one from Agusan River, Mindanao, and one from Sandakan, Borneo, varying from 755 to 1,640 millimeters in length.

Measurements of large specimens of Evenchelys macrurus.

Length.	Head.	Trunk.	Tail.	Depth.
mm.	*mm.*	*mm.*	*mm.*	*mm.*
1,640	134	431	1,075	40
1,464	138	436	890	45
[a] 1,453	150	483	820	52
[b] 1,380	120	520	740	33
[a] 1,260	105	400	755	40
1,000	95	289	616	31

[a] Spawning female.

[b] An aberrant individual from Agusan River, the head and trunk being contained but 1.15 times in the tail. In spite of this it undoubtedly belongs here.

This eel is common in the Philippines, though it is not easy to get specimens, the fishermen usually cutting them up or at least removing the head before taking them to market. It is called *malabanos* in Tagalog, *ogdoc* by the Visayans of Iloilo, and *taguibos* in Cebu.

This fish reaches a length of more than 3 meters and some authors claim it is the largest of all eels, a statement with which I cannot agree, owing to its slenderness; nevertheless it may

easily be the longest. It frequents shallow seas and the mouths of rivers, sometimes ascending the latter, and is found from Natal to Formosa, the Pelew Islands, and Queensland.

Genus **PSEUDECHIDNA** Bleeker

Pseudechidna BLEEKER, Ned. Tijdschr. Dierk. 1 (1863) 272.
Strophidon MCCLELLAND, Calcutta Journ. Nat. Hist. 5 (1844) 187.

A genus of morays notable for the extreme length and slenderness of the compressed body, the origin of the dorsal strongly in advance of the gill opening, and the great number of fin rays, those in the dorsal being about 628, and in the anal about 335. In *Gymnothorax* and *Echidna* there are never more than from 250 to 400 rays in the dorsal and 150 to 280 in the anal. The height of the body is contained from 40 to 55 times in the total length, while the tail is less than twice the length of the head and trunk; the posterior nostrils have no tubes; the teeth are not serrated.

But one species is positively known.

Pseudechidna brummeri Bleeker.

Muræna brummeri BLEEKER, Nat. Tijdschr. Ned. Ind. 17 (1858–59) 137.
Pseudechidna brummeri BLEEKER, Ned. Tijdschr. Dierk. 1 (1863) 272.
Strophidon brummeri BLEEKER, Atlas Ichth. Muræn. 4 (1864) 109, pl. 18, fig. 1; JORDAN and SNYDER, Proc. U. S. Nat. Mus. 23 (1901) 885.
Strophidon polyodon BLEEKER, Atlas Ichth. Muræn. 4 (1864) 109, pl. 19, fig. 3.
Muræna brummeri GÜNTHER, Fische d. Südsee 3 (1910) 420; WEBER and BEAUFORT, Fishes Indo-Austr. Arch. 3 (1916) 359, fig. 179.
Gymnothorax megapterus MAX WEBER, Siboga Exp., Fische (1913) 57, pl. 7, fig. 1.

Depth 40 to 55 in total length, head 12 to 17, and 4.6 to 7.25 in trunk; head and trunk together nearly as long as tail or more than a fourth shorter; head small, weak, lower jaw particularly so; eye covered with skin, 14 to 20 in length of head, 1.75 to 2.5 in snout and just forward of middle of cleft of mouth, which closes completely and is 3.7 to 4 in head; snout acutely rounded, 7 to 8 in head; posterior nostril above anterior margin of eye; dorsal fin begins from one-fourth to one-third the length of head before gill openings; anterior portion of dorsal equal in height to depth of body but posterior portion is 1.5 times the depth of tail; a row of five large pores on each side of jaws and a double row of four on top of snout.

Teeth small, the anterior ones larger, depressible, caninelike; maxillary teeth in one row, imperfectly two rowed, or in two rows on one or both sides; a single row of four to ten teeth on vomer; mandible with twelve to twenty-four teeth in a single row on each side; the forward ones are enlarged and may be irregularly two ranked. When the maxillaries have two rows of teeth the eel is the *polyodon* of Bleeker.

Color in alcohol uniform pale brown; head and especially jaws with numerous dark dots; each pore on head in a dark dot; fins paler, usually with a white margin.

I have two specimens, one from Puerto Galera, Mindoro, the other from Cagayan de Misamis, Mindanao.

Measurements of Pseudechidna brummeri.

	Puerto Galera.	Cagayan de Misamis.		Puerto Galera.	Cagayan de Misamis.
	mm.	*mm.*		*mm.*	*mm.*
Length	410	525	Tail	222	293
Head	28	32	Depth	8.5	9.5
Trunk	160	200	Eye	2	2

A small, exceedingly slender eel with very elongate trunk, attaining a length of 800 millimeters. It occurs from Madagascar and Mauritius to the Riu Kiu Islands and southeast to the New Hebrides, Samoan, and Society Islands.

Genus GYMNOTHORAX Bloch

Gymnothorax BLOCH, Naturg. Ausl. Fische 9 (1795) 83; BLEEKER, Atlas Ichth. Muræn. 4 (1864) 82.

This genus includes those morays in which the posterior nostrils are round or oval openings on top of the head in front of or above the eyes and sometimes provided with a rim but never with a tube; the body is elongate but often thick and heavy, the depth being less than 30 in the length; the teeth are sharp, conical or compressed, not serrated, more or less pointing backward; the jaw teeth are in one or more series, with one or more rows of usually smaller teeth on the vomer; those on the intermaxillary plate are in one or two outer rows and there is a central row of from one to four depressible canines, the posterior ones often being very long and startlingly resembling the erectile fangs of poisonous snakes; Calmette states that they have a poison gland at their base and are truly venomous; sometimes the jaws have additional depressible canines but the total

number in the mouth is not more than ten; the lower jaw often has several pairs of large canines as an inner row near the symphysis. The inner row on the maxillaries disappears with age in most species, becoming a part of the outer row; the teeth are subject to great variation.

Head compressed, with characteristically elevated occipital region, due to the development of the powerful biting muscles; anterior nostrils tubular, on top of snout; eyes small and covered with skin; cleft of mouth reaching behind eyes, often not closing completely; origin of dorsal on head before or above gill openings, which are small slits more or less horizontal or circular.

These morays are common throughout the warmer parts of the Indo-Pacific and Atlantic Oceans and the Mediterranean Sea, often literally swarming in the shallow water about rocks and coral reefs, where some of the species attain a great size. Some of them are among the most beautifully colored of fishes, with rich and variegated hues and intricate, brilliant, often fantastic patterns. They are among the most active of eels, many of them greedy, bold fighters, striking like a snake at their prey.

Many of them are highly variable, so that a great number of nominal species have been described, based largely on color variations or the changes due to age, as large old specimens often diverge widely from the young not only in color but in dentition and proportions. Of the development of the young nothing is known. The sands and pools of the coral reef flats swarm with tiny murænids, mostly *Gymnothorax*, whose specific identity it is often impossible to determine. Like many other families of tropical fishes, it will be impossible to be certain of the morays until someone is able to study them in situ during their life cycle. Many very unlike species bear an extraordinarily close resemblance to each other, while individuals of the same species may have the most diverse appearance, even when of the same size.

Key to the Philippine species of Gymnothorax.

a^1. One or two mesial teeth on intermaxillary, conical, and not longer than outside row.

b^1. Maxillary teeth in one row or in two rows in the very young. G. pictus.

b^2. Maxillary teeth in two rows.. G. thyrsoideus.

a^2. Mesial teeth on intermaxillary long slender depressible fangs, one to four in number.

c^1. Maxillary teeth in two or three rows, the inner row of five or more.

d^1. Marginal teeth of intermaxillary in one row........................ **G. tile.**

d^2. Marginal teeth of intermaxillary in two rows.

e^1. Color uniform brown.. **G. brunneus.**

e^2. Color not uniform brown but spotted or variegated.

f^1. Head 1.7 to 2.9 in trunk; gape 2 to nearly 3 in head. **G. meleagris.**

f^2. Head 4 to 5 in trunk; gape about 3.5 in head..... **G. polyuranodon.**

c^2. Maxillary teeth in one row, or with an inner series of one to four fangs which disappear with age.

g^1. Encircled by fifteen to thirty more or less irregular but definite dark crossbands.

h^1. Crossbands about thirty, about as broad as interspaces, these spotted with darker.................................. **G. punctatofasciatus.**

h^2. Seventeen to twenty-four crossbands, interrupted on belly and usually larger than interspaces.............................. **G. petelli.**

g^2. Body not banded with distinct crossbands.

i^1. Gill openings in a dark brown or black patch..... **G. flavimarginatus.**

i^2. Gill openings not in a dark patch.

j^1. Color uniform brown, dorsal moderately developed, not over half as high as body.. **G. boschi.**

j^2. Coloration not uniform but more or less spotted or variegated.

k^1. Distinct dark spots over entire body, more or less in longitudinal rows.

l^1. Spots smaller than interspaces, smallest or wanting on head. **G. undulatus.**

l^2. Spots larger than interspaces, those on head not smaller. **G. favagineus.**

k^2. Body more or less marbled, reticulated, or with spots forming crossbands.

m^1. More or less distinct white spots on jaws.

n^1. A dark brown or black spot at angle of jaw with a white spot in front of it........................ **G. chilospilus.**

n^2. No dark brown spot at angle of jaw, but a large brown spot behind eye, bordered above and below by white lines or bands.................................. **G. zonipectus.**

m^2. No distinct white spots on jaws.

o^1. A black blotch at angle of mouth, uniting with a black band around chin.................................. **G. philippinus.**

o^2. No black blotch at angle of mouth.

p^1. Vomerine teeth in two series, except in large old specimens, when they are in one row. Yellowish, marbled and reticulated with dark brown or finely mottled with dark and yellowish.................... **G. richardsoni.**

p^2. Vomerine teeth in a single row, or irregular and partially two rowed.

q^1. Color dark brown spotted with lichenlike whitish blotches; vomer with an irregular partially double row of teeth; anal fin with white margin. **G. kidako.**

q^2. Not spotted with lichenlike blotches; no white margin on anal; teeth on vomer in one row; ground color dark with a network of white or yellowish lines.

r^1. Tail much shorter than head and trunk; lines on body and tail very fine...... G. pseudothyrsoideus.

r^2. Tail longer than or nearly equal to head and trunk together.

s^1. Head 2 to 2.6 in trunk; tail longer than head and trunk .... G. undulatus.

s^2. Head 2.75 to 3 in trunk; tail a little longer or shorter than head and trunk...... G. favagineus.

Gymnothorax pictus (Ahl).

Muræna picta AHL, De Muraena et Ophichtho, Thunberg Dissert. 3 (1789) 6, pl. 2, fig. 2; GÜNTHER, Cat. Fishes Brit. Mus. 8 (1870) 116; DAY, Fishes of India (1878–88) 672, pl. 172, fig. 4; WEBER and BEAUFORT, Fishes Indo-Austr. Arch. 3 (1916) 362, figs. 175, 180, 182, 183.

Gymnothorax pictus BLOCH and SCHNEIDER, Syst. Ichth. (1801) 529; BLEEKER, Atlas Ichth. Muræn. 4 (1864) 87, pl. 26, figs. 3 and 4; pl. 28, fig. 3; pl. 29, fig. 1; pl. 45, fig. 3; JORDAN and EVERMANN, Bull. U. S. Fish Comm. 23 (1903) (1905) 103, pl. 19.

Muræna lita RICHARDSON, Voyage Erebus and Terror, Fishes (1844–1848) 84.

Muræna polyophthalmus BLEEKER, Act. Soc. Sci. Indo-neerl. 3 (1858) 15.

Gymnothorax polyophthalmus BLEEKER, Atlas Ichth. Muræn. 4 (1864) 96, pl. 30, fig. 3.

Gymnothorax pictus, litus, and *polyophthalmus* JORDAN and SEALE, Bull. U. S. Bur. Fisheries 25 (1905) (1906) 198, 199.

Gymnothorax pictus and *litus* JORDAN and RICHARDSON, Bull. U. S. Bur. Fisheries 27 (1907) (1908) 239.

Depth 14.4 to over 20 in total length; head 2.4 to 2.7 in trunk and 7 to 8 in length; head and trunk together the same length, or somewhat shorter than tail in my specimens; in one specimen which has had the tail bitten off and healed over, head and trunk are slightly longer than tail; eyes 8.3 to 9 or 10 in head and 1.4 to about 1.8 in the bluntly rounded snout which is 5.5 to over 6 in head; mouth closes completely, and is 2.4 to nearly 3 in head; origin of dorsal very slightly in advance of gill openings.

Teeth sharp, pointed, in one row in maxillaries; the very young have two rows, the inner gradually disappearing; a single row of ten to fourteen stouter teeth on intermaxillary plate, with a single central tooth which is not fanglike and is no larger than the others; in very young specimens there is an outer row of small teeth inclosing two or three central teeth; teeth on vomer in two

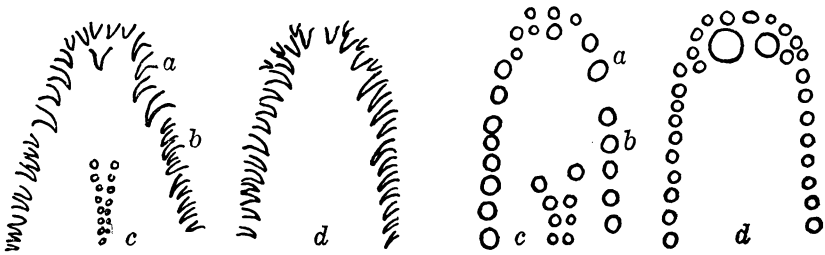

FIG. 12. *Gymnothorax pictus* (Ahl), dentition of two specimens, showing variation; *a*, intermaxillary; *b*, maxillaries; *c*, vomer; *d*, mandibles. × 2.

short rows, the forward end more or less forked; the very young have but one short series; teeth in lower jaws in two rows in the young, the outer series of small teeth disappearing with age and remaining more or less evident around tip of jaw.

Color in alcohol handsome brownish gray, flecked and speckled with innumerable small to minute black spots, which are few or absent beneath, and on anal fin; even the eyes are spotted; in the very young the ground color is yellow, with three irregular lengthwise rows of circular blackish spots about the size of eye, which soon have a yellow center; as the fish grows the spots become irregular and the yellow center increases in size till they are broken up and the adult pattern finally develops; but in many specimens traces of the first color pattern are evident, the spots being confluent and forming more or less ring-shaped figures.

I have examined several specimens from Calapan, Mindoro, and the species has been recorded from Samar by Peters, from southern Negros by Jordan and Seale, and from Ticao, Cuyo, and Cagayancillo Islands by Jordan and Richardson.

This handsome and distinct eel reaches a length of nearly 800 millimeters and occurs on reefs and along seacoasts from the east coast of Africa, Natal, and Madagascar to Australia, the islands of the south Pacific, Hawaii, and the Riu Kiu Islands.

Gymnothorax thyrsoideus (Richardson).

Muræna thyrsoidea RICHARDSON, Voyage Sulphur, Ichth. (1844) 111; Voyage Erebus and Terror, Fishes (1844–48) 91; GÜNTHER, Cat. Fishes Brit. Mus. **8** (1870) 113; DAY, Fishes of India (1878–88) 672, pl. 142, fig. 3; WEBER and BEAUFORT, Fishes Indo-Austr. Arch. **3** (1916) 365.

Gymnothorax prosopeion BLEEKER, Atlas Ichth. Muræn. **4** (1864) 88, pl. 39, fig. 3.

Gymnothorax thyrsoideus BLEEKER, Atlas Ichth. Muræn. **4** (1864) 103 (description after Cantor); JORDAN and SEALE, Bull. U. S. Bur. Fisheries **25** (1905) (1906) 198.

Depth 14.7 to 20.5 in length, head 8.58 to 8.9, and 2.5 to 2.7 in trunk; head and trunk together 1.39 to 1.45 in tail. ("Height 17–21; head 9 to more than 10, thrice in trunk. Head and body somewhat shorter than tail."—Weber and Beaufort.) Eye circular and rather small, 9.2 to 12.5 in head and 1.4 to 2 in the short, blunt, rounded snout; lower jaw curved so that the horizontal mouth does not close completely; gape reaches far behind eyes and is 2.72 to 3 in head; dorsal begins on occiput 0.4 to 0.5 the length of head in advance of gill opening; vertical fins low, dorsal less than one-half the height of body; gill opening with a dark mark; maxillary with twelve to fourteen rather small compressed teeth in outer row and from eight to ten longer, pointed, depressible teeth in inner row which is curved and separated by a broad interspace from the outer teeth; intermaxillary plate with ten to fourteen teeth in outer row, all large, stout, fixed, with recurved points, except those at tip of jaw, which are small; one or two central teeth scarcely larger than the others and hardly depressible; vomer with a double row of low, broad, rounded teeth, diverging anteriorly, the anterior tooth in each row the largest; six or seven pairs of teeth on vomer, sometimes with a long irregular row extending posteriorly, seven or eight in number; lower jaw with about twenty-five teeth on each side, those of anterior half largest, and an inner row of three to six larger teeth on each side at forward end.

Color uniform light yellowish, thickly dotted and spotted with purplish brown, leaving the ground color as pale spots; anterior half of head uniform dark purplish brown without markings; the spots and dots may coalesce and form marblings, especially on tail; belly not paler; fins colored like body.

Color in alcohol, similar but much duller.

Head, trunk, and tail much compressed, head deep. Width of head less than one-third its length. Here described from

Measurements of Gymnothorax thyrsoideus.

	Sitanki.	Leyte.	Guimaras.
	mm.	*mm.*	*mm.*
Length	515	410	430
Depth	35	20	24
Head	60	46	50
Trunk	155	124	125
Tail	300	240	255
Eye	5	5	4
Gape	22	16	17

three specimens, one of which I obtained at Sitanki, one caught at Cabalian, Leyte, by Mr. Lopez, and one at Jordan, Guimaras, by Mr. Montalban.

This species is easily recognized by the dentition. While my specimens have a black mark around the gill openings the only author who seems to have noticed this character is Day who says "gill opening sometimes with a black mark around it." Jordan states that a living Samoan specimen had a pale edge to the dorsal, but the fins do not ordinarily have a pale margin.

This species reaches a length of 650 millimeters and has a wide range, occurring from the Seychelles and the coast of Arabia to China, Guam, West Australia, the Samoas, Navigator, and Tonga Isands.

Gymnothorax tile (Hamilton Buchanan).

Murænophis tile HAMILTON BUCHANAN, Fishes Ganges (1822) 18, 363.
Muræna vermiculata RICHARDSON, Voyage Erebus and Terror, Fishes (1844–48) 92.
Muræna gracilis RICHARDSON, Voyage Erebus and Terror, Fishes (1844–48) 92.
Gymnothorax tile BLEEKER, Atlas Ichth. Muræn. 4 (1864) 97, pl. 34, fig. 1.
Echidna tile PETERS, Monatsber. Akad. Wiss. Berlin (1868) 275.
Muræna tile GÜNTHER, Cat. Fishes Brit. Mus. 8 (1870) 112; DAY, Fishes of India (1878–88) 668, pl. 170, fig. 4; WEBER and BEAUFORT, Fishes Indo-Austr. Arch. 3 (1916) 370.

Depth 16 to 23 in total length, head 7.4 to nearly 8, and a little less than 3 to 3.3 in trunk; head and trunk together equal or slightly exceed length of tail; eye 12 to 14 in head, 1.5 to 2 in the prominent snout and nearer angle of mouth; gape, measured from the mandibulary symphysis, 3.8 to 4.2 in head; origin of dorsal slightly before gill openings, which are about the size of eyes; the conical teeth are in two rows in maxillaries, an outer row of fourteen or more, enlarged posteriorly, and an inner row of five to eight larger teeth; a single row of twelve to fourteen large teeth on intermaxillary plate, sometimes with a few small ones intermingled, and a middle row of three still larger canines; twenty or more blunt conical teeth on vomer, in two rows or irregularly biserial; lower jaws with about twenty-four teeth on each side, in two rows at anterior portion.

Color in alcohol brown or brownish black, with very many irregular minute light specks of unequal size which disappear more or less in old specimens on anterior half of body, but which are distinct on dorsal fin and tail.

This species was collected by Jagor on a coral reef near Láuang, on the north coast of Samar, but has not been obtained since then in the Philippines though it undoubtedly is widely distributed in the Archipelago. It is abundant in the seas and river mouths of India, being common in the Hooghly at Calcutta, and is found in the Indian Ocean from Ile de Bourbon northeastward and in the East Indies to Borneo and Ceram. It attains a length of over 600 millimeters.

Gymnothorax brunneus sp. nov.

Depth 17.7 in length, $6\frac{2}{9}$ in trunk and $2\frac{1}{9}$ in head which is 8.42 in length and 2.94 in trunk; head and trunk together about half the length of head shorter than tail; eyes same size as gill openings and 9.5 in head and twice in snout, which is bluntly rounded and goes 4.75 in head; mouth $2\frac{3}{8}$ in head; posterior nostrils above and just a little forward of center of eyes; jaw teeth all small and sharp pointed; maxillaries with an outer row of sixteen minute, compressed teeth and an inner row of ten pointed, depressible teeth more than twice as large; intermaxillary plate with fifteen much stouter teeth and two mesial depressible teeth but little larger, all with recurved points; vomer with ten blunt, rounded teeth in a single row; lower jaw with about twenty-five small teeth on each side, more or less irregular, and six pairs of larger depressible teeth forming a double inner row near symphysis, all with their points directed backward.

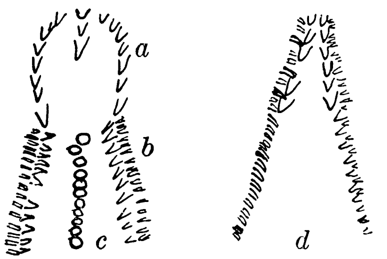

FIG. 13. *Gymnothorax brunneus* sp. nov., dentition; *a*, intermaxillary; *b*, maxillaries; *c*, vomer; *d*, mandibles. × 4.

Color uniform brown, snout paler, and chin pale tan; fins paler brown than body.

Body compressed; dorsal beginning not more than the diameter of an eye in advance of the gill opening; dorsal moderate. its height at anus one-third the depth of body; anal low.

Here described from a specimen in the Bureau of Science collection, probably from Puerto Galera, Mindoro. Its dimensions are as follows: Length, 160 millimeters; head, 19; trunk, 56; tail, 85; depth, 9.

This eel is separated from similarly colored species of *Gymnothorax* by the dentition. The outer maxillary row of minute

teeth is difficult to make out, the inner row being apparently continuous with those of the intermaxillary plate. This may be the young of *G. monochrous*, but Bleeker's description fails to show its identity, and I cannot place it under the *Muræna boschi* of Weber and Beaufort.

Gymnothorax meleagris (Shaw).

Muræna meleagris SHAW, Nat. Misc. (1809) pl. 220; RICHARDSON, Voyage Erebus and Terror, Fishes (1844–48) 93; GÜNTHER, Fische d. Südsee 3 (1910) 410; WEBER and BEAUFORT, Fishes Indo-Austr. Arch. 3 (1916) 367.

Gymnothorax duivenbodei BLEEKER, Atlas Ichth. Muræn. 4 (1864) 89, pl. 25, fig. 1.

Gymnothorax buroensis BLEEKER, Atlas Ichth. Muræn. 4 (1864) 90, pl. 46, fig. 1.

Gymnothorax meleagris JORDAN and EVERMANN, Bull. U. S. Fish Comm. 23 (1903) (1905) 94.

Gymnothorax meleagris and *buroensis* JORDAN and SEALE, Bull. U. S. Bur. Fisheries 25 (1905) (1906) 197, 199.

Greatest depth 1.56 in head, 3.2 in trunk, which is about twice (2.05) as long as head; interorbital space one-sixth the length of head, which is three times as long as its greatest breadth; the large round eye 1.5 in the narrow, rather blunt snout, and 7.8 in head; origin of dorsal eleven-thirteenths the length of head from tip of snout; gill openings smaller than eye; cleft of mouth horizontal, closing completely, reaching more than an eye diameter beyond eye, $2\frac{1}{6}$ in head; teeth of upper jaw in two series, the outer one of fifteen or twenty small, depressible, compressed sharp teeth which are directed backwards; inner row has six or eight long, sharp, depressible canines; there are indications of a third row of canines on one side; outer row of teeth continued on intermaxillary plate, those at tip of jaw smallest; a group of depressible canines in the middle line, the second and third of the median series the longest teeth of mouth; each mandible with about twenty-five or thirty small, sharp, compressed, subequal teeth, their points directed backward; a group of larger canines near tip of lower jaw; all teeth depressible; teeth on vomer small, pointed, a single series of six anteriorly, merging into an irregular double row of about nine more posteriorly.

Color in alcohol purplish brown apparently overlying a gray ground color, with spots of dark or blackish brown becoming fused and definitely arranged in crossbands toward and upon tail, the lighter color showing as irregular whitish flecks or spots

between, especially on underside of tail; upper jaws and cranium almost uniform purplish brown; belly and throat pale, densely speckled with small dark flecks.

Here described from a mutilated female about to spawn, collected at Cabalian, Leyte, May 19, 1921. The tail has been bitten off and healed, and a flap of skin with the characteristic white tip of the caudal has grown out to form a pseudo fin. While the specimen does not agree with any of the published figures, its proportions and dentition place it here and it is undoubtedly a variety of *Gymnothorax meleagris*, probably closest to Günther's variety "f."[10] Its dimensions are: Head, 39 millimeters; trunk, 80; tail, 112; gape, 18; eye, 5; snout, 7.5.

This species reaches a meter in length and ranges from the east coast of Africa to the East Indies, Hawaii, Australia, and the South Sea Islands. Günther and Weber and Beaufort have united many species under this name; most of them unquestionably belong here.

Gymnothorax polyuranodon Bleeker.

Muræna polyuranodon BLEEKER, Nat. Tijdschr. Ned. Ind. **5** (1853) 248.

Gymnothorax polyuranodon BLEEKER, Atlas Ichth. Muræn. **4** (1864) 89, pl. 30, fig. 2.

Muræna polyuranodon GÜNTHER, Cat. Fishes Brit. Mus. **8** (1870) 114; Fische d. Südsee **3** (1910) 421; BOULENGER, Ann. & Mag. Nat. Hist. VI **15** (1895) 187; WEBER and BEAUFORT, Fishes Indo-Austr. Arch. **3** (1916) 369, fig. 185.

Height 19 to 28; head 9 to more than 11, 4 to 5 times in trunk. Tail somewhat shorter than head and trunk. Eye 10–12, more than 1.5 in snout, situated above middle of cleft of mouth, which goes more or less than 3½ times in length of head, is horizontal and closes completely. Origin of dorsal slightly before gill openings, which are a little wider than the eye. Teeth conical, with the sharp point directed backwards, in the maxillaries in 2 or 3 series, on the intermaxillary plate in 2 peripheral series, the teeth of the inner series stouter, in the centre 1 or 2 compressed, recurved, moveable teeth; on vomer a single series of 5 to 10 teeth. Mandibulary teeth posteriorly uni- to triserial, anteriorly stouter and bi- to quadriserial. Yellowish brown, with irregular rounded, more or less confluent black spots. On the head the spots coalesce into more or less complete longitudinal bands, separated by light longitudinal streaks. Length 700 mm.—*Weber and Beaufort.*

A specimen only 275 millimeters long was collected by E. H. Taylor in Saub River, Cotabato, Mindanao, April 29, 1923. Boulenger records the species from Palawan.

[10] Fische d. Südsee **3** (1910) 411.

This eel occurs along the coasts and ascends rivers throughout the East Indies and southeast to the Fiji Islands.

Gymnothorax punctatofasciatus Bleeker.

Muræna catenata BLEEKER, Act. Soc. Sci. Indo-neerl. 1 (1856) 66 (not Richardson).

Gymnothorax punctatofasciatus BLEEKER, Ned. Tijdschr. Dierk. 1 (1863) 167; Atlas Ichth. Muræn. 4 (1864) 99, pl. 31, fig. 4.

Muræna punctatofasciata GÜNTHER, Cat. Fishes Brit. Mus. 8 (1870) 106; DAY, Fishes of India (1878–88) 669, pl. 169, fig. 4.

Depth 22.5 to 27.7 in total length, head 8.1 to 8.3, and 2.7 in trunk; tail a little longer than head and trunk together; head and trunk contained about 1.2 in tail; eyes halfway between tip of snout and angle of mouth, $9\frac{2}{3}$ to 10.8 in head, and twice in the narrow but rather bluntly rounded snout; mouth large, its gape 2.8 to 3.4 in head; dorsal low, its origin before gill openings, which are a fifth larger than eyes; maxillaries each with about sixteen small, sharp-pointed teeth and two inner canines in a row near forward end; about twelve teeth around margin of intermaxillary teeth and three needlelike canines forming a central row; eight small teeth in a single row on vomer; about twenty teeth on each side of lower jaw, and two or three much larger ones on each side near symphysis, some of which may be in an inner row.

Color in alcohol brown or yellowish or grayish brown, with twenty-eight to thirty-five (thirty and thirty-one in our specimens) dark brown, more or less irregular rings, some of which may be incomplete or divided, but most of which are complete. The interspaces are about as wide as the rings and like the head are closely dotted and spotted with darker brown.

Here described from a specimen 225 millimeters long, collected at Cagayan de Misamis, Mindanao, and from another, 236 millimeters long, probably from Cebu but possibly from Taytay, Palawan. Previously recorded from the Philippines by Jordan and Seale from Negros Island. This small and easily recognized moray ranges from Zanzibar to the Philippines.

Since the above was written I have seen a specimen in the collection of the University of the Philippines, with thirty-four rings. Another specimen, 455 millimeters long, with twenty-eight rings, was collected by G. A. Lopez of the Bureau of Science, at Cebu, Cebu.

Gymnothorax petelli Bleeker.

Muræna petelli BLEEKER, Nat. Tijdschr. Ned. Ind. 11 (1856) 84; WEBER and BEAUFORT, Fishes Indo-Austr. Arch. 3 (1916) 372.

Gymnothorax petelli BLEEKER, Atlas Ichth. Muræn. 4 (1864) 99, pl. 32, fig. 1; JORDAN and SEALE, Bull. U. S. Fish Comm. 25 (1905) (1906) 197; JORDAN and RICHARDSON, Bull. U. S. Bur. Fisheries 27 (1907) (1908) 240.

Gymnothorax leucacme JENKINS, Bull. U. S. Bur. Fisheries 21 (1902) 427, fig. 2.

Gymnothorax waialuae SNYDER, Bull. U. S. Fish Comm. 22 (1902) 520, pl. 6.

Height 18 to 20, head 8–9$\frac{2}{3}$, 2$\frac{2}{5}$–3 times in trunk. Tail longer than head and trunk. Eye 9 to 10, situated somewhat nearer to the end of the snout than to the corner of the mouth. Snout rather pointed, not twice as long as eye. Cleft of mouth about 2$\frac{1}{4}$ times in head. Mouth not shutting completely in old specimens. Dorsal rather low, beginning before gill openings, which are about as wide as eyes. Maxillaries with a series of 12–14 conical, somewhat compressed teeth, anteriorly with an inner series of 3 long depressible teeth, which disappear with age. On intermaxillary plate a peripheral series of about 12 rather long depressible teeth, mesially with 2 or 3 larger fang-like ones. Vomer with a single series of 3 conical teeth. Mandibles with 18–25 teeth on each side in a single series. Brown, with 17–24 dark cross bands, which are generally larger than the interspaces between them. They are interrupted on the belly. The first band on the snout, the third through origin of dorsal. In old examples most of the bands are broken into spots, but the anterior dorsal bands remain distinct. Length 1,100 mm.—*Weber and Beaufort.*

This eel is known from the Philippines from a very young specimen collected at Calayan Island north of Luzon and described by Jordan and Richardson. It undoubtedly occurs throughout the Philippines but has been overlooked by collectors. This handsome moray occurs from Mauritius and the Red Sea to the Hawaiian Islands and the Samoas.

Gymnothorax flavimarginatus (Rüppell).

Muræna flavimarginata RÜPPELL, Atlas Reise Nördl. Afrika, Fische des Rothen Meeres (1828) 119, pl. 30, fig. 3; GÜNTHER, Fische d. Südsee 3 (1910) 417; WEBER and BEAUFORT, Fishes Indo-Austr. Arch. 3 (1916) 374.

Gymnothorax formosus BLEEKER, Atlas Ichth. Muræn. 4 (1864) 94, pl. 30, fig. 1.

Gymnothorax javanicus BLEEKER, Atlas Ichth. Muræn. 4 (1864) 95, pl. 35, fig. 2.

Gymnothorax flavimarginatus BLEEKER, Atlas Ichth. Muræn. 4 (1864) 95, pl. 32, fig. 2; pl. 34, fig. 3; JORDAN and EVERMANN, Bull. U. S. Fish Comm. 23 (1903) (1905) 99, pl. 17.

Gymnothorax flavomarginatus JORDAN and SEALE, Bull. U. S. Bur. Fisheries 25 (1905) (1906) 200; JORDAN and RICHARDSON, Bull. U. S. Bur. Fisheries 27 (1907) (1908) 240.

Depth 9.74 to 22 in length, head 6.95 to 9 in length, and from 2.75 to 3.5 in trunk; head and trunk together as long as or a

little shorter than tail; eyes of small to medium size, a little forward of middle of gape, 9 to 17.3 in head and 1.9 to 2.6 in the rather short, oblong, bluntly rounded snout; mouth large, its cleft from a little more than twice to 2.5 in head; the lower jaw becomes much curved in large old specimens so that the mouth cannot be closed completely; dorsal of moderate height, less than half the depth of body, its origin slightly in advance of gill openings, which are much larger than eyes; posterior nostrils somewhat tubulate, slightly anterior to or hardly above front margin of eyes; maxillary teeth slender, compressed, sharp pointed, larger anteriorly, ten or twelve on each side; young examples are said to have an inner anterior row of three long and slender teeth; intermaxillary plate has an outer row of eight to ten large sharp teeth with two mesial depressible canines, the posterior one being very long; nineteen or twenty teeth on each side of lower jaw, the second and third from symphysis being very large canines; all jaw teeth strongly directed backwards; vomer has about six pairs of teeth arranged in a broadly diverging fork, followed by a few teeth forming a single posterior row; vomerine teeth small and sharp pointed; the teeth forming one side of the Y are often missing, as is the case in my smallest specimen.

Fresh specimens are everywhere of a rich purplish brown, which becomes paler and more or less yellowish in alcohol; the back and sides are densely mottled and spotted with very dark purplish brown to blackish, the spots larger and more irregular posteriorly; the fins colored and blotched like the body, but darker; the spots on the head are very small and are absent on the jaws and snout, the last very dark in color; the inside of the mouth is also dark purplish brown.

Color in alcohol ranges from yellowish to dark brown, and dark purplish brown, everywhere mottled or spotted and blotched with deep brown or blackish; these spots may fuse to form larger irregular patches; fins concolorous but darker, dorsal dusky or blackish; dorsal and anal usually with a pale yellowish or whitish margin, this sometimes visible only posteriorly and on caudal or entirely absent; a dark spot usually at corner of mouth; gill openings always in a large black or dark brown blotch; the spots on head small to very small; jaws and snout unspotted and usually very dark.

A very robust female specimen, containing eggs, nearly ready to spawn, was caught April 23, 1922, at Monja Island, which lies at the entrance to Manila Bay. Its dimensions are as

follows: Length, 1,225 millimeters; depth, 120; head, 175; trunk, 420; tail, 630; gape, 85.

A huge specimen captured December 21, 1922, on Subunguin Reef, near the town of Bondoc, Tayabas, had the following dimensions; Length, 1,510 millimeters; depth, 155; head, 217; tail, 692; mouth, 105; snout, 33; eye, 12.5. The tail is shorter than the head and trunk by over 18 per cent of its own length, but it has probably had the tip bitten off, as it is wide and notched at the end instead of tapering to a point. The projecting lower jaw is very much curved so that the cavernous mouth cannot be closed. Such individuals as this, with their enormous head and jaws and thick, bulky body, enable one to realize their strength and biting power and to understand why they are held in such dread by the fishermen.

The Bureau of Science collection also contains a specimen 680 millimeters long from Zamboanga, Mindanao, and a typical head, 133 millimeters in length, from Balabac Island.

This eel looks something like *Gymnothorax thyrsoideus*, but its body is more robust and less strongly compressed, the dark patch at the gill opening is larger and more evident, the color of the head is different, and the dentition is entirely unlike.

A large species, reaching a length of 1,600 millimeters, and of wide distribution, occurring throughout the warm parts of the Indian and Pacific Oceans, north to Formosa and Hawaii, south to Madagascar and the Austral Islands.

Gymnothorax boschi Bleeker.

Muræna boschi BLEEKER, Verh. Bat. Gen. 25 (1853) Muræna 52; WEBER and BEAUFORT, Fishes Indo-Austr. Arch. 3 (1916) 386.

Gymnothorax boschi BLEEKER, Atlas Ichth. Muræn. 4 (1864) 105, pl. 46, fig. 3.

Gymnothorax monochrous BLEEKER, Atlas Ichth. Muræn. 4 (1864) 106, pl. 47, fig. 2.

Muræna afra GÜNTHER, Cat. Fishes Brit. Mus. 8 (1870) 123; pro parte.

Depth 11 in total length and 1.78 in head, which is 2.6 in trunk and about 7 in total length; head and trunk together exceed tail by a third of head, tail a little less than 91 per cent of them or about 47.54 per cent of total length; eye moderately large, about 10 in head and 1 $\frac{7}{9}$ in the broad, rather blunt snout which is a little more than 5.5 in head; mouth large, 2.25 in head; interorbital space about three-fourths snout; greatest width of head about 3.75 in its length; posterior nostril over anterior margin of eye; origin of dorsal in advance of gill openings about 0.3

the length of head; gill openings about two-thirds the diameter of eye; teeth long, pointed, coarse, but very irregular in size, directed backwards, the posterior ones much the smallest; about ten on each maxilla and a row of twelve much larger ones on intermaxillary, with three depressible canines on central line; one small sharp tooth far back on vomer; about twenty teeth of very uneven size but mostly large and sharp pointed on each mandible, with two large depressible canines forming an inner series near symphysis.

A stout, heavy-bodied eel, with the dorsal well developed, but less than half as high as body; anal very low.

Color in alcohol uniform umber or blackish brown, belly paler.

Here described from a large eviscerated specimen having a length of 610 millimeters, Bureau of Science collection No. 4432, from Zamboanga. It is nearest to Bleeker's *Gymnothorax monochrous* which Weber and Beaufort have united with his *G. boschi*. I have seen what is undoubtedly this species in the fish markets in Manila and southward, but the specimens have always been cut up so that I have been unable to secure them for study.

There is a living *Gymnothorax* in the Bureau of Science aquarium which does not agree with any described species, but I place it here rather than describe it as new. It has a thick heavy body, 640 millimeters long, in which the depth is $10\frac{1}{3}$ times; head 1.5 times as long as depth and 7.1 in total length and 2.55 in trunk; tail equal to head and trunk together; eyes very full and rounded, with brown iris, and contained 10 times in head and twice in the long narrow snout; width of interorbital space equals $\frac{7}{9}$ the length of snout; jaws curved and do not close completely, gape 2.3 in head; origin of dorsal one-third the length of head in advance of gill openings, which are about seven-ninths as large as eyes; dorsal well developed, its height along middle of trunk 2.5 in body depth and its height over anus half the depth at that point; anal fin thick and rather low.

It is of course not possible to count the teeth, but they are in a single row throughout, with three mesial canines on the intermaxillary plate, the posterior one being very long and needlelike.

Color uniform liver brown, somewhat darker dorsally and on dorsal fin; head much paler, being uniform pale clay or pale yellowish brown; belly similar, much paler than rest of trunk and tail. There is a narrow and rather inconspicuous very pale yellowish margin to dorsal fin; no marks, blotches, or mottling anywhere.

This specimen was collected at either Puerto Galera or Calapan, Mindoro.

This eel has the dorsal margin characteristic of *Gymnothorax hepaticus* or *albimarginatus,* and of some specimens of *Gymnothorax flavimarginatus,* but lacks the very high dorsal characteristic of the first two while the relative proportions of depth and length are very different.

It is probable that the *Muræna hepatica* of Weber and Beaufort and their *Muræna boschi* overlap and include five nominal species, and that a full series of living material would result in the recognition of three distinct species.

Gymnothorax undulatus (Lacépède). Plate 9, fig. 1.

Murænophis undulata LACÉPÈDE, Hist. Nat. Poissons 5 (1803) 629, 644.
Muræna fimbriata BENNETT, Proc. Comm. Zool. Soc. 1 (1831) 168.
Muræna bullata RICHARDSON, Zool. Voyage Erebus and Terror, Fishes (1844–48) 86.
Muræna cancellata RICHARDSON, Zool. Voyage Erebus and Terror, Fishes (1844–48) 87, pl. 46, figs. 1–5.
Gymnothorax isingleenoides BLEEKER, Atlas Ichth. Muræn. 4 (1864) 91, pl. 35, fig. 1; pl. 36, fig. 1.
Gymnothorax bullatus BLEEKER, Atlas Ichth. Muræn. 4 (1864) 91, pl. 27, fig. 2; pl. 43, fig. 3.
Gymnothorax cancellatus BLEEKER, Atlas Ichth. Muræn. 4 (1864) 93, pl. 32, fig. 3; pl. 33, fig. 2; pl. 39, fig. 1.
Gymnothorax agassizi BLEEKER, Atlas Ichth. Muræn. 4 (1864) 95, pl. 41, fig. 2.
Muræna fimbriata DAY, Fishes of India (1878–88) 670, pl. 172, fig. 1.
Gymnothorax undulatus JORDAN and EVERMANN, Bull. U. S. Fish Comm. 23 (1903) (1905) 98, pl. 16.
Muræna undulata GÜNTHER, Fische d. Südsee 3 (1910) 413, pl. 164, 165; WEBER and BEAUFORT, Fishes Indo-Austr. Arch. 3 (1916) 376, fig. 186.

Depth 8.25 to 19.5 in length over all; head 2 to 2.6 in trunk and 6.5 to nearly 8 in total length; tail varies from slightly more to half a head length more than length of head and trunk together; eye moderately large, 8.4 to 8.75 in head and 1.5 to 1.75 in snout, which is usually rather long and narrow, with rounded tip and 4 to 5.6 in head; mouth large, usually closing completely, 2 to 2.24 in head; origin of dorsal 0.22 to 0.19 the length of head before gill opening, which is as large or three-fourths as large as eye; interorbital space varies from diameter of eye to length of snout; greatest width of head from 2.25 to 4.25 in its length; vertical fins well developed, dorsal less than half the depth of body, anal much lower; maxillary teeth in a single row of about

fifteen (twelve to twenty) small, compressed, backward-pointed teeth in each jaw; in younger specimens an inner row of one to three longer, erect, fanglike depressible teeth; outer row continuous on intermaxillary plate with a row of much larger caninelike teeth, ten to sixteen in number; a row of three long needlelike depressible fangs on center of maxillary plate, the posterior one longest; from sixteen to twenty small, compressed, backward-pointed teeth on each side of lower jaw, and from four to eight large immovable canines around symphysis; a single row of five to eight small teeth on vomer.

Color of a living specimen in the Bureau of Science aquarium, collected at Calapan, Mindoro, light olive gray, everywhere specked with exceedingly numerous and minute dark dots, throat and belly paler than other parts; about three longitudinal rows of large circular or irregular spots, mostly not larger than eyes; dorsal fin with bandlike spots which may connect with upper row on body; spots on head few and much smaller.

An alcoholic specimen differs from the above only in having the gray slightly suffused with a reddish brown, especially about the head and snout. A specimen from Puerto Galera, Mindoro, and one from Samal Island in the Gulf of Davao are typical of the variety *fimbriata*, having a ground color of reddish brown, with smaller and fewer spots; otherwise they are like the living specimen described. In all the above the dorsal and the anal have a more or less evident white border.

A specimen from Dumaguete is the *Gymnothorax agassizi* of Bleeker.

In a large specimen of unknown locality, 660 millimeters long, the ground color is yellowish gray, thickly overspread with dark spots and markings so that it is reduced to more or less of an indeterminate network of whitish or yellowish lines and narrow irregular spaces, the animal therefore marbled with light and dark; posteriorly the dark spots are more definite, larger, in longitudinal rows, and coalesce to form vague transverse bands. This specimen is remarkable for the extreme depth of the head, as shown in the figure. I have also examined three small specimens in the collection of the Ateneo de Manila, obtained at Tandag, Surigao.

A large and powerful, fiercely biting moray, said to reach a length of 2 meters. It is an exceedingly variable and widespread species, previously recorded from Manila by Kner, and from Zamboanga by Seale and Bean under the name of *G. fimbriatus*. It occurs from Madagascar, Mauritius, the east coast of Africa,

and the Red Sea to the Riu Kiu Islands, Hawaii, Australia, and everywhere among the South Sea Islands; abundant throughout its range.

Gymnothorax favagineus Bloch and Schneider. Plate 11, fig. 2.

Gymnothorax favagineus BLOCH and SCHNEIDER, Syst. Ichth. (1801) 525.

Gymnothorax isingteena BLEEKER, Atlas Ichth. Muræn. 4 (1864) 92, pl. 37, fig. 1.

Gymnothorax tessellatus BLEEKER, Atlas Ichth. Muræn. 4 (1864) 93, pl. 27, fig. 3; pl. 28, fig. 1.

Muræna tessellata GÜNTHER, Cat. Fishes Brit. Mus. 8 (1870) 106.

Gymnothorax favageneus JORDAN and SEALE, Bull. U. S. Bur. Fisheries 25 (1905) (1906) 199.

Muræna favaginea WEBER and BEAUFORT, Fishes Indo-Austr. Arch. 3 (1916) 378, fig. 187.

Depth 15.5 to 21.5 in total length; head 7.5 to 9 in length and 2.75 to 3 in trunk; tail a little longer or a little shorter than head and trunk together; eye 10 to 12 in head and twice in snout; the wide mouth $2\frac{1}{3}$ to 2.5 in head; length of anterior nostril tube about twice in eye; origin of dorsal 0.657 the length of head from snout; height of dorsal over middle of trunk nearly equal to half depth of body; anal much less developed than dorsal; maxillary teeth in one row, rather small and uniform in size, compressed, pointed, directed backwards, about fifteen in each jaw, the first one larger and caniniform; a single series of canines forms a row around margin of maxillary plate, with three much larger depressible canines forming a central row; these separated by a gap and then a row of very small teeth down vomer, about eight in number; fifteen or more teeth on each side of mandible, first pair small, followed by three pairs of large ones, the remaining teeth medium sized, all pointed and directed backward.

A very well defined species of handsome and distinct coloration, separating into well-marked varieties; in the variety *isingteena* the whole animal is covered with large rounded or polygonal black spots which are separated by distinct interspaces of the pale whitish or yellowish olive ground color, the spots mostly wider than interspaces; the variety *favageneus* has the spots separated by narrow lines, the ground color being reduced to a broad network around the spots.

I have examined one alcoholic specimen from Manila, belonging to the variety *isingteena*, with dimensions as follows: Length, 540 millimeters; head, 70; trunk, 195; tail, 575. There is also

a stuffed Philippine specimen in the museum of the Ateneo de Manila.

This eel attains a length of considerably over a meter, and occurs from the east coast of Africa and Mauritius Island to the south coast of Arabia, throughout the East Indies, and on to the New Hebrides and the Paumotus.

Gymnothorax chilospilus Bleeker. Plate 11, fig. 1.

Gymnothorax chilosphilus BLEEKER, Atlas Ichth. Muræn. 4 (1864) 103, pl. 45, fig. 2.

Gymnothorax sagenodeta BLEEKER, Atlas Ichth. Muræn. 4 (1864) 100, pl. 40, fig. 4 (not of Richardson).

Gymnothorax samalensis SEALE, Philip. Journ. Sci. § A 4 (1909) 492.

Muræna chilospilus GÜNTHER, Fische d. Südsee 3 (1910) 415; WEBER and BEAUFORT, Fishes Indo-Austr. Arch. 3 (1916) 379, fig. 188.

Depth 15 to more than 19 in length in my specimens, head 7 to 7.7 (8.5, Weber and Beaufort) and 2 to 2.66 in trunk; tail a little longer than head and trunk together, exceeding them by a tenth or more, occasionally by a distance equal to 0.73 of head; eyes moderately large, circular, 8.6 to 9.6 in head, located about over middle of mouth, 1.4 to 1.6 times in the rather oblong, bluntly pointed snout; gape 2.3 to 2.8 in head; fins moderately developed, anal low, dorsal less than half the body depth, origin of dorsal slightly (rarely 0.4 the length of head) in advance of gill openings, which are much narrower than width of eyes; posterior nostrils small, not at all tubulate, over anterior portion of pupil; maxillary teeth small to very small, compressed, backward pointing, eight to fourteen in number; sometimes there is an inner row of two to five much longer, depressible, fanglike teeth; intermaxillary plate has an outer row of twelve to fourteen teeth, largest posteriorly, the most anterior ones usually much smaller; one specimen with very small teeth alternating with the fourteen large ones; three or four mesial depressible fangs, first one very small, third and fourth usually very long; vomer with nine to twelve small teeth in a single row, anterior ones largest; ten to twenty sharp, backward-pointed teeth, with a short inner row of two or three much stouter ones near tip, on each side of lower jaw.

Color in alcohol brownish to brown, with wavy, anastomosing, more or less complete dark brown crossbands, more evident on tail and dorsal and anal fins, sometimes practically wanting, especially anteriorly; belly and throat paler, yellowish to grayish; head brown, with a dark brown spot more or less evident at

angle of mouth; pores on jaws in white spots, with a large white spot before angle of mouth on lower jaw; sometimes a white streak on upper jaw just in front of angle of mouth.

I have examined four specimens in the Bureau of Science collection, one of them being the type of *Gymnothorax samalensis*, collected at Samal Island, in the Gulf of Davao, Mindanao; the others are without labels. They vary in length from 169 to 232 millimeters. One of them, a female ready to spawn, has almost no trace of crossbars and is almost uniform brown, with very pale belly and throat. Another specimen has the markings exceedingly well developed, strongly contrasting with the specimen just mentioned, and bears a remarkable resemblance in color to *G. richardsoni*.

This species may be distinguished in any color phase by its characteristic jaw markings and its dentition.

This is a small species, reaching a length of not more than a third of a meter, and has a narrow, compressed body and tail. It occurs throughout the East Indies to the Philippines on the north and southeast to the Samoas and Tahiti.

Since I wrote the above Mr. G. A. Lopez obtained a specimen in December, 1922, at the barrio of Anajawan, on the southern coast of Leyte. This specimen, which has a length of 268 millimeters, is a female with nearly mature eggs; in coloration it is very close to Bleeker's figure of *G. sagenodeta*.

Gymnothorax zonipectis Seale. Plate 11, fig. 3.

> *Gymnothorax zonipectis* SEALE, Occ. Papers Bishop Mus. 4 (1906) 7, fig. 1.
>
> *Gymnothorax indong* SEALE, Philip. Journ. Sci. § A 4 (1909) 491.
>
> *Muræna zonipectis* GÜNTHER, Fische d. Südsee 3 (1910) 415, with text figure; WEBER and BEAUFORT, Fishes Indo-Austr. Arch. 3 (1916) 381, fig. 181.

Depth 19.25 in total length and 2.5 in head, which goes 7.7 times in entire length and 2.48 in trunk; tail longer than head and trunk together by almost three-fourths the length of head; eyes twice in snout and about 10 in head; snout long, narrow, with rounded tip, interorbital space equal to diameter of eye; mouth large with curved jaws so that it cannot close completely, and opens much farther back on one side than on the other, its greatest extent twice in head; tube of anterior nostril nearly one-third the length of snout; posterior nostril over anterior margin of iris; dorsal low, its origin about one-sixth the length of head

in advance of gill opening, which is four-fifths as large as eye; greatest width of head a little more than 3.5 in its length.

Teeth all conical, sharp, and strongly slanted backward, in a single row in both jaws; ten maxillary teeth on each side and about twelve much larger ones on intermaxillary, with three long depressible fangs in a central row, the posterior one very long; five small, short, pointed teeth far back on vomer; twenty to twenty-two teeth on each side of lower jaw, the first two pairs being large fangs.

Color in life clear brilliant brown with five longitudinal rows of irregularly shaped black spots and blotches which form more or less broken and irregular crossbands, narrower than the interspaces, and best developed on fins; head more or less ruddy and mottled with white and brown; a large blackish blotch behind eyes has a short narrow white line above it and a more distinct, wider, and longer white band which extends to upper lip below eyes; another white stripe from front margin of eyes to middle of maxillary; a black blotch in angle of jaws bordered anteriorly by a narrow elongate white stripe on mandible; a white median line in the the dusky area under posterior portion of mandibles; chin and throat with narrow white transverse lines; pores of jaws white.

Color in alcohol similar but faded, especially on head which is dull colored, the white becoming dingy or disappearing.

Here described from the type of *Gymnothorax indong*, Bureau of Science collection No. 4445, from Zamboanga, Mindanao. This handsome little eel reaches a length of more than 450 millimeters, and is known elsewhere from Tahiti, Rotuma, and the south coast of Java.

Gymnothorax philippinus Jordan and Seale.

Gymnothorax philippinus JORDAN and SEALE, Bull. U. S. Bur. Fisheries 26 (1906) (1907) 7, fig. 2.

Head 3.45 in trunk; length of head and trunk greater than tail by a distance equal to length of snout; eye rather large, 1.9 in snout; length of mouth to angle 2.4 in head; a single row of sharp pointed teeth in lower jaw; teeth in upper jaw in a single row, reinforced by 3 or 4 additional teeth in palatine series; three large fang-like vomerine teeth in front, with a row of smaller ones extending back; anterior teeth large canines; fins of moderate height.

Color in spirits, everywhere powdered with yellow and brown, lighter on belly and chin, darker on posterior two-thirds of body, which shows rather wide indistinct darker bands; a distinct black blotch at angle of

mouth, which unites with a black band around chin; a second dusky blotch midway between angle of mouth and gill opening; gill openings uncolored; fins dark without white margins.

I have not seen the above-named and perhaps doubtful species, which was described from the type and only specimen, 23 inches (about 585 millimeters) long, and came either from Manila Bay or from near Iloilo.

Gymnothorax richardsoni Bleeker. Plate 11, fig. 4.

Muræna richardsonii BLEEKER, Nat. Tijdschr. Ned. Ind. 3 (1852) 296; GÜNTHER, Fische d. Südsee 3 (1910) 414.

Gymnothorax richardsoni BLEEKER, Atlas Ichth. Muræn. 4 (1864) 100, pl. 42, fig. 2; EVERMANN and SEALE, Bull. U. S. Bur. Fisheries 26 (1906) 56.

Gymnothorax richardsonii JORDAN and RICHARDSON, Bull. U. S. Bur. Fisheries 27 (1907) (1908) 240.

Gymnothorax scoliodon BLEEKER, Atlas Ichth. Muræn. 4 (1864) 101, pl. 40, fig. 2.

Gymnothorax ceramensis BLEEKER, Atlas Ichth. Muræn. 4 (1864) 101, pl. 33, fig. 3.

Muræna richardsoni WEBER and BEAUFORT, Fishes Indo-Austr. Arch. 3 (1916) 383, fig. 189.

Depth 12 to 21.1 in total length, head 5.75 to 8, and 2 to 2.78 in trunk; tail approximately the length of head and trunk or it may be as much as 0.14 longer or shorter; eyes moderately large, 8 to 11.6 in head, and 1.25 to 2 in the short snout, which goes 5 to 7.5 in head; the large horizontal mouth closes entirely, and is 2.2 to 2.6 in head; origin of dorsal a little before or over gill openings, which are as wide as or smaller than eyes; teeth vary much with age; maxillaries with twelve to fourteen short compressed teeth in outer row and one to four much longer depressible canines in an anterior inner row, or with age maxillary teeth reduced to five, six, or eight, with no inner row; intermaxillary plate with an outer row of eight to sixteen teeth hardly larger, and one to four, usually two or three, depressible mesial canines, the posterior ones much the longest; occasionally they are lacking; vomerine teeth small and highly variable, from eight or ten in a single row, or five pairs, through all sorts of irregularities to twenty or more partially or completely biserial; lower jaw with from twelve to twenty teeth on each side, and often with one to three pairs of larger teeth forming inner rows near symphysis.

Color of living specimens light grayish, everywhere marked with irregular, dendritic, anastomosing purplish to purplish

brown marblings, which usually form more or less definite transverse bands, especially on tail; belly and throat paler, the markings there much reduced or forming only irregular spots and marks; on the head they may fuse so that the ground color merely shows as more or less stellate spots on sides; no dark patch at angle of mouth, though inside of mouth is often marked with dark flecks; no dark patch around gill openings.

In alcohol the colors are usually much duller, the ground color ordinarily becoming brownish or yellowish and the markings sometimes nearly or quite obsolete. Occasionally specimens are mottled with light and dark, the vertical crossbands and reticulations but little evident.

This species is common in the Philippines, and in the coral sand beaches at Sitanki and at similar localities it swarms in countless numbers. I have examined numerous specimens, ranging in length from 150 to 322 millimeters, collected at Sitanki, Davao, Dumaguete, Cabalian on Leyte Island, Caldera Bay, Mindanao, and Puerto Galera, Mindoro. It has been recorded from reefs near Cebu, by Günther; from San Fabian, Pangasinan, by Evermann and Seale; and from Sibuyan, by Jordan and Richardson. The last named state their specimen had "corner of mouth with a dark streak, above and below (in front) which is a larger pale spot." I have a specimen 290 millimeters long from Cabalian, Leyte, which agrees in the main with *Gymnothorax richardsoni* but has a small dark streak at corner of mouth. It is probable that this mark does occur, though rarely, in this species. In body color and general appearance this eel is often indistinguishable from certain other species, such as *pictus, chilospilus,* and *undulatus,* so that it is very difficult to arrive at a definite conclusion with regard to certain specimens, especially where the species is so variable as is the present one. From *pictus* it may easily be separated by the long fangs on the intermaxillary plate, but when the colors and markings are faded it may be impossible to separate it from the other two. The presence of so-called scale pouches on the skin, formed by the crisscrossing of skin folds, is a character strongly stressed by certain authors, but it occurs in so many species that I have not used it as a diagnostic character and attach no particular importance to it. This species has a rather compressed form, is of small or medium size, not reaching a meter in length, and in life is one of our handsomest eels. It is very widespread, occurring from Zanzibar and Socotra to the Philippines, Australia, and the islands of the South Pacific.

Gymnothorax kidako (Schlegel).

Muræna kidako SCHLEGEL, Fauna Japonica, Poiss. (1846) 266, pl. 117.
Muræna similis RICHARDSON, Voyage Erebus and Terror, Fishes (1844–48) 83.
Muræna nubila GÜNTHER, Cat. Fishes Brit. Mus. **8** (1870) 117, pro parte syn. et text.
Gymnothorax kidako JORDAN and SNYDER, Proc. U. S. Nat. Mus. **23** (1901) 881.

Depth 2.12 in head and 16.37 in total length; head 7.7 in total length, 4.17 in tail, and 2.53 in trunk; head and trunk together a little shorter than tail, which is a little more than 54 per cent of the whole length; eyes contained 10.2 in head and twice in snout; width of gill openings four-fifths the diameter of eyes; mouth large, its cleft 2.2 in head; maxillaries have sixteen to eighteen small teeth, becoming smaller posteriorly, with two to three longer depressible teeth forming an inner row opposite anterior end of outer row; intermaxillary plate with about twelve large, pointed, fixed teeth in outer row and three mesial, needlelike, depressible canines, the posterior one longest; eight small rounded teeth forming an irregular partially double row on vomer; twenty to twenty-five teeth in each lower jaw with three pairs of larger teeth near symphysis. Origin of dorsal approximately one-third the length of head forward of gill openings, its height a trifle more than one-third the body depth at middle of trunk or at anus.

Color in alcohol rich purplish dark brown, somewhat darker posteriorly, spotted with irregular lichenlike whitish blotches, which join to form irregular transverse bands on trunk and dorsal fin; on posterior half of tail they become reduced to three and then two rows of spots; anal fin with a dark brown band and a very distinct white margin; buccal grooves with dark streaks; lining of mouth and throat dark purplish and apparently angle of mouth had a dark spot; dorsal colored like body.

Here described from a specimen taken by Gregorio Lopez, of the Bureau of Science, from the stomach of a sea snake, *Laticauda colubrina*, at Santo Domingo de Basco, Batan Island, Batanes Province, November 20, 1921. It bears a very close resemblance in both color and shape to the figure of *Aemasia lichenosa* Jordan and Snyder.[11] Jordan and Snyder note the resemblance between these two eels but state that the pale edge of the anal in *Gymnothorax kidako* separates it at sight. In

[11] Proc. U. S. Nat. Mus. **23** (1901) 883, fig. 20.

this specimen the measurements of the eyes and snout are only approximate and it is impossible to note the coloration of the anterior part of the head (except that there was apparently a black or very dark spot in the angle of the mouth) because digestion had begun in the snake's stomach, removing the skin of the anterior two-thirds of the head and partially destroying the eyes; the rest of it is uninjured.

I have compared this specimen very carefully with Schlegel's original description, as well as with that given by Jordan and Snyder, and cannot place it elsewhere although in color it is very much unlike Schlegel's figure. Jordan and Snyder state that the teeth are "all in single series," but this does not agree with the dentition of the Bureau of Science specimen. But Schlegel says "Toutes ces dents sont du reste assez sujettes à varier tant sous le rapport de leur nombre que sous celui de leur grandeur et de leur forme; il arrive même quelquefois, que les dents sont assez irrégulières et que celles de la deuxieme moitié de la mâchoire supérieure se trouvent disposées sur deux ou même sur plusieurs rangées."

This species reaches a length of 3 feet (1 meter) and is common on the coasts of Japan, where Schlegel states it is much sought after, owing to its exquisite flavor.

Our specimen has the following dimensions: Length, 393 millimeters; head, 51; trunk, 129; tail, 213; depth, 24; eye, 5; snout, 10; gape, 23; gill opening, 4.

Gymnothorax pseudothyrsoideus Bleeker.

Muræna pseudothyrsoidea BLEEKER, Nat. Tijdschr. Ned. Ind. **3** (1852) 778; WEBER and BEAUFORT, Fishes Indo-Austr. Arch. **3** (1916) 384.

Gymnothorax makassariensis BLEEKER, Atlas Ichth. Muræn. **4** (1864) 104, pl. 46, fig. 2.

Gymnothorax pseudothyrsoideus BLEEKER, Atlas Ichth. Muræn. **4** (1864) 104, pl. 37, fig. 3; JORDAN and RICHARDSON, Mem. Carnegie Mus. **4** (1909) 173.

Depth 14 to 20 in length, head 7 to 8, and 2.6 to 2.9 in trunk; tail shorter than head and trunk together; eye 8 to 12 in head and one and a half times to twice in snout; the wide mouth does not shut completely in large specimens, its gape 2.1 to 2.3 in head; vertical fins rather well developed, dorsal beginning one-fifth to one-half the length of head in advance of gill openings, which are as large as or smaller than eyes; maxillaries with one row of about twelve compressed teeth, young specimens with an inner row of one to three larger ones at forward end; intermaxillary plate with an outer row of ten to twelve teeth

and a central row of one to three canines; vomer with a single row of from three to nine small teeth; mandibles with a single row of about nineteen on each side; in young specimens the teeth near symphysis may be irregularly two rowed.

Color in alcohol brownish to rather dark brown, finely reticulated or marbled everywhere with lighter, or with more or less conspicuous very fine white or yellow lines; chin and belly scarcely paler than upper parts; occasionally almost uniform dark brown. There is no black around gill opening and no light border to fins except at tip of tail. This species reaches a length of over 560 millimeters.

There is a small specimen of this moray in the museum of Santo Tomas, presumably collected in Manila Bay. This species was described by Bleeker from Celebes and Amboina, and occurs rarely from Zanzibar and Muscat to Formosa and Darnley Island, which lies between New Guinea and Queensland, Australia.

Genus **ANARCHIAS** Jordan and Seale

Anarchias JORDAN and SEALE, Bull. U. S. Bur. Fisheries 25 (1905) (1906) 204.

This genus differs chiefly from *Gymnothorax,* which it otherwise closely resembles, in having no anal; from *Uropterygius* it differs in having a fully developed dorsal fin.

Anarchias reticulatus sp. nov. Plate 9, fig. 3.

Depth 18 to 21.7 in length and 2.2 to 2.5 in head, which goes from 8.1 to 8.27 in length and 2.8 to 2.95 in trunk; head and trunk together shorter than tail, being contained in it 1.08 to 1.14; eye small, 12.5 to 15 in head and 1.7 to 2 in snout, which is $7\frac{1}{3}$ to $7\frac{1}{2}$ in head; mouth wide, closing completely, its gape 2.93 to 3.14 in head; two rows of teeth in both jaws; outer row of very small, fixed, pointed teeth, inner of depressible caninelike teeth of much greater length, usually more than twice as long; two still longer median canines on intermaxillary plate, the second one very long and fanglike; a short row of six small, sharp-pointed, depressible teeth on vomer.

Head narrow, jaws subequal, lower inclined to project slightly; gill openings smaller than eyes; dorsal beginning far forward of gill openings; anal absent or reduced to a rudiment which is confluent with the small caudal.

Color in alcohol gray or warm reddish brown, everywhere covered with irregular dark lines and markings, more or less

dendritic and anastomosing or reticulate; the markings wider and darker above, so that dorsal half is more or less dusky, ventral half relatively pale; interspaces between markings sprinkled with very minute dark dots.

Here described from three small specimens, 122, 179, and 182 millimeters in length, dug out of the coral sands at Sitanki.

This is closely related to *Uropterygius marmoratus* but seems to be sufficiently distinct from *Gymnomuræna marmorata* as defined by Weber and Beaufort.

Genus **UROPTERYGIUS** Rüppell

Uropterygius RÜPPEL, Neue Wirbelthiere, Fische (1835) 83; JORDAN and SNYDER, Proc. U. S. Nat. Mus. **23** (1901) 886.

Gymnomuræna WEBER and BEAUFORT, Fishes Indo-Austr. Arch. **3** (1916) 392.

This group comprises long or very long morays in which the fins are altogether wanting or developed only at tip of tail; the typical species have the tail as long as or longer than head and trunk, but it may be considerably shorter; anterior nostrils in tubes, posterior nostrils with low rims only; eye small, covered by skin; cleft of mouth reaching behind eye, closing almost or quite completely; no pectorals; gill openings small, in middle of body height, or above or below; teeth in two or three series, more or less compressed, pointed, the larger ones depressible; vomer with one or two rows of pointed teeth.

Coral-reef or shore-dwelling eels of the warmer parts of the Indian and Pacific Oceans.

Key to the species of Uropterygius.

a^1. Color uniform brown .... **U. concolor.**

a^2. More or less spotted, marbled, or reticulated.

b^1. Gill openings about middle of height, two or three rows of teeth in jaws .... **U. marmoratus.**

b^2. Gill openings high above middle line; teeth very numerous, forming bands .... **U. supraforatus.**

Uropterygius concolor Rüppell.

Uropterygius concolor RÜPPELL, Neue Wirbelthiere, Fische (1835) 83; JORDAN and SEALE, Proc. U. S. Nat. Mus. **28** (1905) 772.

Gymnomuræna concolor WEBER and BEAUFORT, Fishes Indo-Austr. Arch. **3** (1916) 395.

Robust, smooth, and finless, the elongate subcylindrical trunk becoming compressed posteriorly; tip of tail with a very small caudal into which the vestigial dorsal and anal fins merge; origin of dorsal about twice diameter of eye forward of tip of tail.

Depth about 18 to 33 in length; head from 7.1 to nearly 10.4; tail equal to, somewhat shorter, or somewhat longer than head and trunk.

A specimen from Zamboanga has the following dimensions: Length, 790 millimeters; head, 76; tail, 357; trunk, 357; depth, 36. Eye 6 millimeters in diameter and contained twice in snout, which is heavy, blunt, and rounded and contained 6⅝ in head; mouth wide, closing completely, its horizontal cleft about 3 in head and reaching far beyond eye which is forward of middle of jaw; anterior nostrils on front of snout; posterior nostrils on top of head forward of eyes and with well-developed rims; their interspace twice in distance from tip of snout to posterior margin of eye.

The heavy jaws are subequal, with two rows of teeth in each; those in outer series much smaller, compressed, and close set; in mandible outer row is composed of numerous sharp-pointed teeth, inner row of a few long canines; in both jaws teeth in inner series much the longer and depressible; outer maxillary series continued on intermaxillary plate, the teeth much smaller and inclosing numerous longer, depressible, irregularly placed teeth; a row of five or six large, pointed canines on vomer. Color uniform dark chocolate brown, skin thick and leathery.

Another small specimen from the same locality has the following measurements: Length, 330 millimeters; head, 40; tail, 170; trunk, 120; depth, 17; color reddish brown. Pores on lips and chin large and conspicuous as in Bleeker's figure of *Gymnomuræna pantherina*. This specimen resembles *Uropterygius marmoratus* in some respects but has the dentition of *concolor*. Five small specimens from Calapan, Mindoro, ranging in length from 106 to 115 millimeters, are typical in every respect except in their greater proportionate depth. The pores on jaws and snout are very noticeable in these specimens. Another specimen, from Iba, Zambales, having a length of 244 millimeters, is also typical. Previously recorded from southern Negros by Jordan and Seale.

A widely distributed eel, but according to Günther not common anywhere. It is found from the Red Sea and Mauritius to the Philippines, Australia, and the Society Islands.

Uropterygius marmoratus (Lacépède).

Gymnomuræna marmorata LACÉPÈDE, Hist. Nat. Poissons **5** (1803) 648; DAY, Fishes of India (1878–88) 675; GÜNTHER, Fische d. Südsee **3** (1910) 425; WEBER and BEAUFORT, Fishes Indo-Austr. Arch. **3** (1916) 397, figs. 193, 194.

Gymnomuræna pantherina BLEEKER, Atlas Ichth. Muræn. 4 (1864) 113, pl. 31, fig. 3.

Gymnomuræna xanthopterus BLEEKER, Atlas Ichth. Muræn. 4 (1864) 114, pl. 20, fig. 4.

Gymnomuræna micropterus BLEEKER, Atlas Ichth. Muræn. 4 (1864) 115, pl. 20, fig. 2.

Uropterygius marmoratus JORDAN and EVERMANN, Bull. U. S. Fish Comm. 23 (1903) (1905) 111, fig. 33.

Depth 14 to nearly 21 in total length (19 to 26, according to Weber and Beaufort); head 8.1 to nearly 11 in total length and 2.75 to 3.86 in trunk; head and trunk together 1.09 to 1.2 in tail, which is from one-half to four-fifths of head longer than head and trunk together in my specimens; eye small, 10 to 15 in head and 1.6 to 2 in the rounded snout; mouth wide, 2.7 to 3 in head, and closing completely; anterior nostrils with a conspicuous tube, posterior ones with a rim or short tube, according to age; teeth in jaws in two rows in young specimens, in three rows in older ones, outer row composed of very small, pointed, fixed teeth; inner row or rows of much larger and therefore less numerous, long, depressible canines; the two outer rows of maxillary teeth continued around intermaxillary plate and inclosing two to several larger, depressible canines; vomer with a short row of seven or eight tiny teeth in my specimens; larger examples have them more numerous and in two rows anteriorly; both dorsal and anal entirely absent.

In alcohol a pale yellowish or gray ground color, everywhere reticulated or marbled with more or less anastomosing, dendritic, purplish dark markings which are very numerous and coarser dorsally, finer and less numerous below, so that throat and belly are pale.

I have two small specimens from Sitanki, 153 and 166 millimeters in length. The smaller one is a female nearly ready to spawn, and her swollen trunk is in very marked contrast to her slender head and tail. This specimen, though very small and apparently adult, seems to agree in all essentials with *G. marmoratus*, the head being contained nearly 11 times in total length, and the color being characteristic. A third specimen, locality unknown, 106 millimeters long, agrees with the others except in color; it is blackish brown with numerous darker marblings which are very indistinct on the dark ground color.

This eel reaches a length of more than two feet (60 centimeters) and is found throughout the tropical Indian and Pacific Oceans from Zanzibar to the Philippines, Hawaii, Samoa, and the Marquesas.

Uropterygius supraforatus (Regan).

Gymnomuræna supraforata REGAN, Ann. & Mag. Nat. Hist. VIII 4 (1909) 439; GÜNTHER, Fische d. Südsee 3 (1910) 426, figure in text.

Depth 18.5 in total length, head 10.5 to 11, and 4.6 in trunk; head and trunk together a little shorter than (1.09 in) tail; eyes large, 7.7 in head and about 1.3 in the broad, rounded snout, forward of middle of the large mouth which closes completely and is 1.9 to twice in head; posterior nostrils behind middle of eye, with elevated rims; gill openings high up, located four-thirteenths of depth below dorsal profile; vertical fins very low, poorly developed, dorsal ridge beginning about length of head, anal less than that forward of tip of caudal, with which they are confluent. Teeth excessively numerous, all depressible; in both upper and lower jaws an outer row of very small, pointed, laterally compressed teeth after which comes a band of similar but slightly higher teeth, containing four rows in upper jaws and three or four in mandible; bands taper posteriorly to one or two rows; then follow two or three rows of very long, sharp, depressible, needlelike canines, arranged in two rows anteriorly, in three rows on the maxillaries, the innermost row being conspicuously the largest; the mandible with three rows of long depressible canines, those of innermost row largest; vomer with two slender, short, sharp-pointed teeth; according to Regan the vomerine teeth form a short band. A median row of three long depressible canines on the intermaxillaries.

FIG. 14. *Uropterygius supraforatus* (Regan), dentition; *a*, upper jaw; *b*, lower jaw. × 1.5.

A moderately slender eel with rather blunt tail, the skin very thick and leathery.

Color in alcohol pale yellowish brown, with numerous, often circular, dark reddish spots which often tend to form vertical series, especially posteriorly; spots smaller and more numerous on sides of head, jaws, and throat.

I have examined one specimen of this very distinct species, obtained from the stomach of a sea snake, at Cresta de Gallo, a rock near Sibuyan. Previously known from a specimen from Savaii and three smaller ones from Tahiti. My specimen is practically identical in size with the type in the British Museum, its measurements being as follows: Length, 277 millimeters; head, 27; trunk, 125; tail, 155; eye, 3.5; snout, 4.5; gape, 14.

ILLUSTRATIONS

[Drawings on plates not credited to Espinosa were made by M. Ligaya.]

PLATE 1

FIG. 1. *Anguilla spengeli* M. Weber; × 0.5.
2. *Ariosoma obud* sp. nov.; × 1.
3. *Uroconger lepturus* (Richardson); × 1.

PLATE 2

FIG. 1. *Muraenichthys malabonensis* sp. nov; × 1.
2. *Cirrhimuraena oliveri* (Seale); × 1.

PLATE 3

Taenioconger chapmani sp. nov.; × 1.

PLATE 4

Chlevastes colubrinus (Boddaert); × 1.

PLATE 5

Ophichthus manilensis sp. nov.; × 2.

PLATE 6

FIG. 1. *Lamnostoma orientalis* (McClelland); × 1.
2. *Caecula taylori* sp. nov.; × 1.

PLATE 7

Moringua robusta sp. nov.; × 0.5.

PLATE 8

Moringua cagayana Seale; × 1.

PLATE 9

FIG. 1. *Gymnothorax undulatus* (Lacépède); × 0.25.
2. *Aphthalmichthys macrocephalus* Bleeker; × 1.
3. *Anarchias reticulatus* sp. nov.; × 1.

PLATE 10

FIG. 1. *Muraenesox cinereus* (Forskål), head, from a photograph.
2. *Myrichthys maculosus* Cuvier, from a photograph.
3. *Echidna nebulosa* (Ahl), from a color sketch by T. S. Espinosa.
4. *Echidna rhodochilus* Bleeker; × 2.

PLATE 11

1. *Gymnothorax chilospilus* Bleeker; × 2.
2. *Gymnothorax favagineus* Bloch and Schneider, from a photograph.
3. *Gymnothorax zonipectis* Seale, from a color sketch made at Zamboanga, by T. S. Espinosa.
4. *Gymnothorax richardsoni* Bleeker, from a color sketch made at Sitanki, by T. S. Espinosa; × 0.5.

TEXT FIGURES

[Original drawings by Herre.]

FIG. 1. *Anguilla celebesensis* Kaup, dentition; *a*, vomer and maxillaries; *b*, mandibles. After Weber and Beaufort.

2. *Muraenichthys gymnopterus* Bleeker, dentition; *a*, intermaxillaries; *b*, maxillaries; *c*, vomer; *d*, mandibles. × 3.

3. *Pisodonophis boro* (Hamilton Buchanan), dentition; *a*, intermaxillary plate; *b*, maxillaries; *c*, vomer; *d*, mandibles. × 2. After Weber and Beaufort.

4. *Ophichthus cephalozona* (Bleeker), dentition; *a*, intermaxillary plate; *b*, maxillaries; *c*, vomer; *d*, mandibles. × 2.5.

5. *Ophichthus grandoculis* (Cantor), dentition; *a*, intermaxillary plate; *b*, maxillaries; *c*, vomer; *d*, mandibles. × 3.

6. *Ophichthus celebicus* (Bleeker), dentition; *a*, intermaxillary plate; *b*, maxillaries; *c*, vomer; *d*, mandible. × 3.

7. *Caecula taylori* sp. nov., dentition; *a*, intermaxillary plate; *b*, maxillaries; *c*, vomer; *d*, mandibles. × 4.

8. *Moringua cagayana* Seale, dentition; *a*, intermaxillaries; *b*, maxillaries; *c*, vomer; *d*, mandibles. × 5.

9. *Aphthalmichthys macrocephalus* Bleeker, dentition; *a*, intermaxillary plate; *b*, maxillaries; *c*, vomer; *d*, mandibles. × 4.

10. *Echidna delicatula* (Kaup), dentition; *a*, intermaxillary plate; *b*, maxillaries; *c*, vomer; *d*, mandibles. × 4.

11. *Echidna amblyodon* Bleeker, dentition; *a*, intermaxillary plate; *b*, maxillaries; *c*, vomer; *d*, mandibles. × 4.

12. *Gymnothorax pictus* (Ahl), dentition of two specimens, showing variation; *a*, intermaxillary; *b*, maxillaries; *c*, vomer; *d*, mandibles. × 2.

13. *Gymnothorax brunneus* sp. nov., dentition; *a*, intermaxillary; *b*, maxillaries; *c*, vomer; *d*, mandibles. × 4.

14. *Uropterygius supraforatus* (Regan), dentition; *a*, upper jaw; *b*, lower jaw. × 1.5.

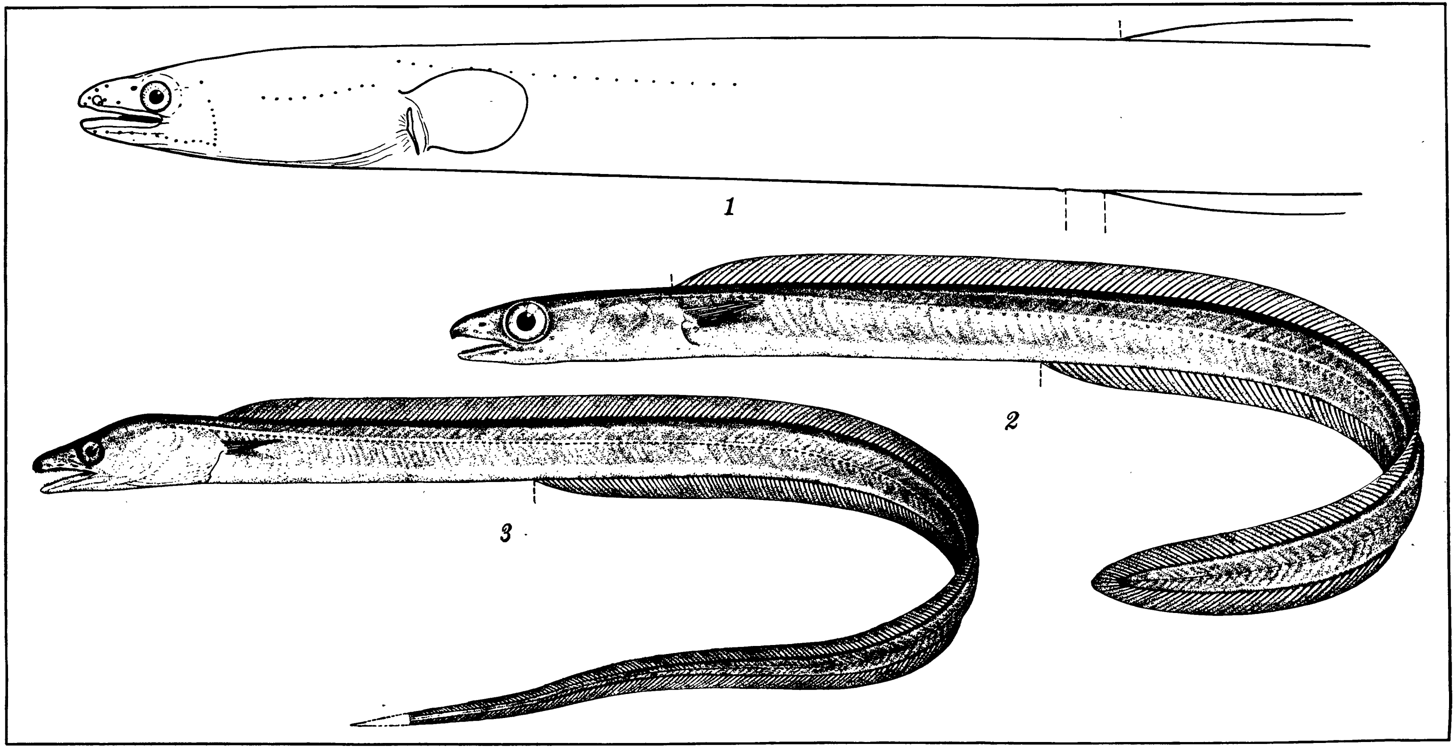

PLATE 1.

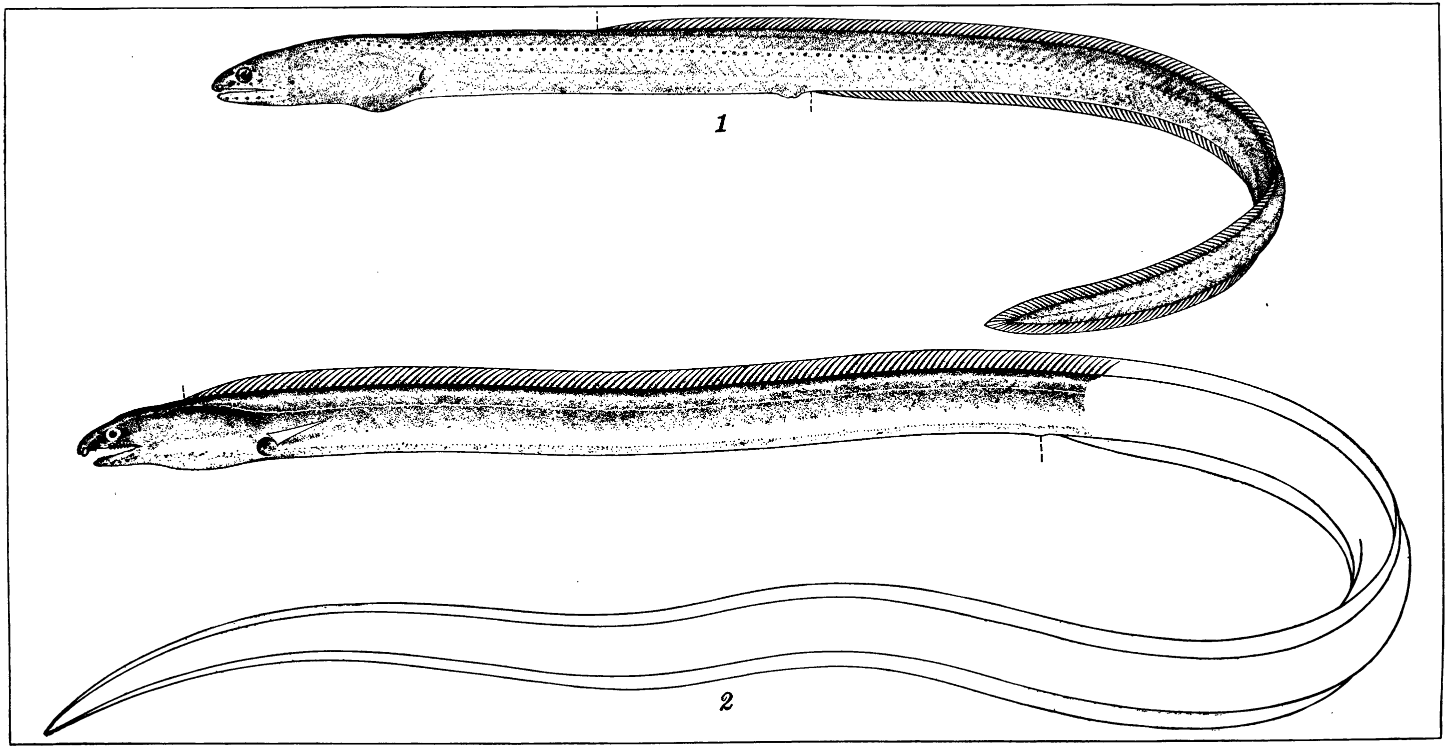

PLATE 2.

PLATE 3. TÆNIOCONGER CHAPMANI SP. NOV.

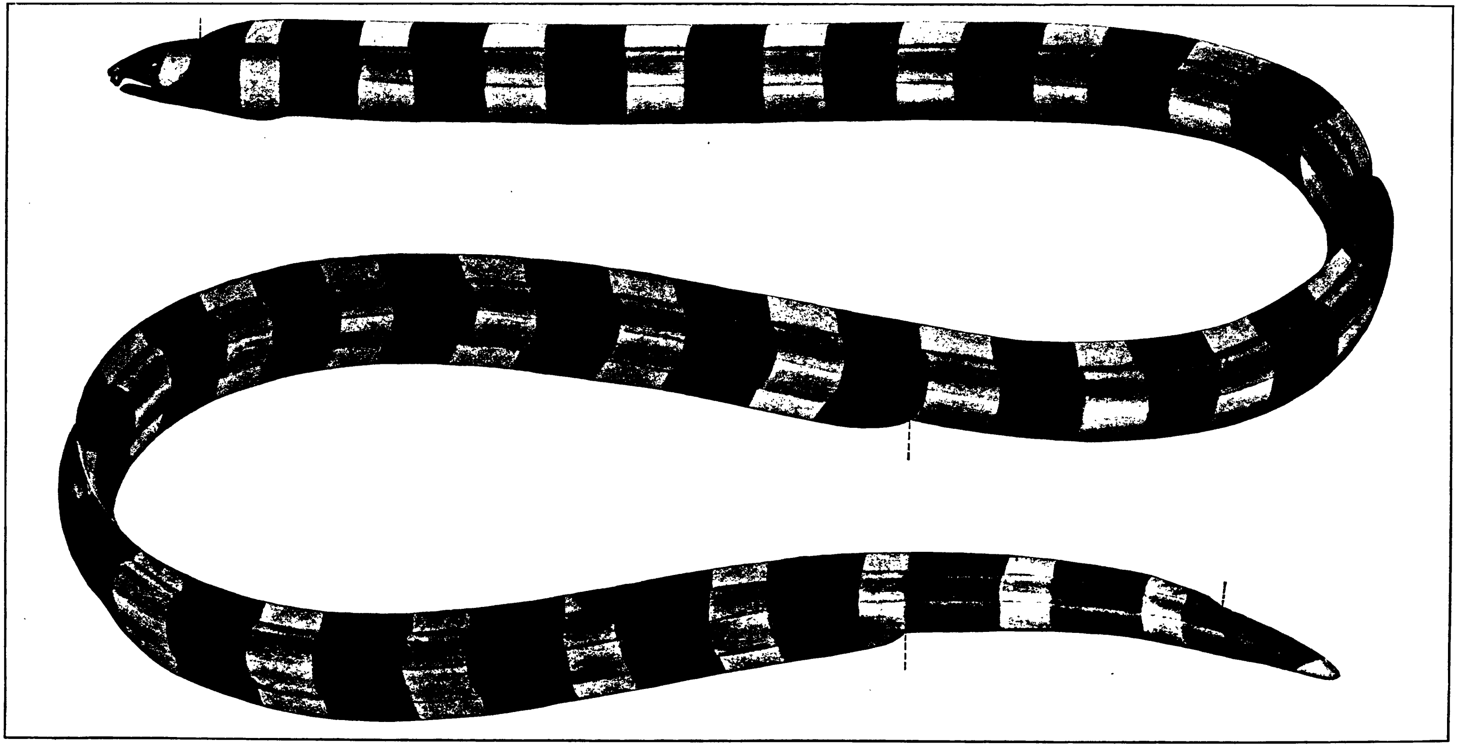

PLATE 4. CHLEVASTES COLUBRINUS (BODDAERT).

PLATE 5. OPHICHTHUS MANILENSIS SP. NOV.

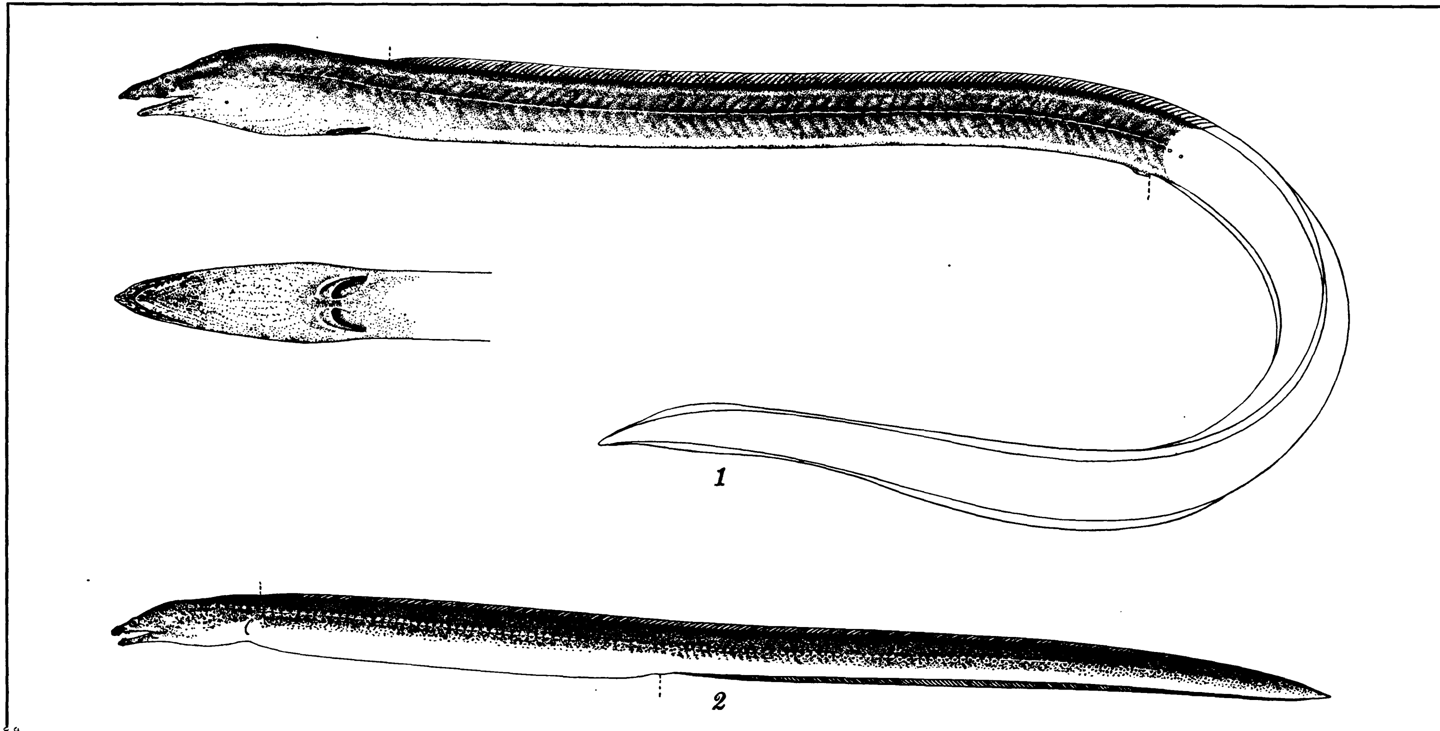

PLATE 6.

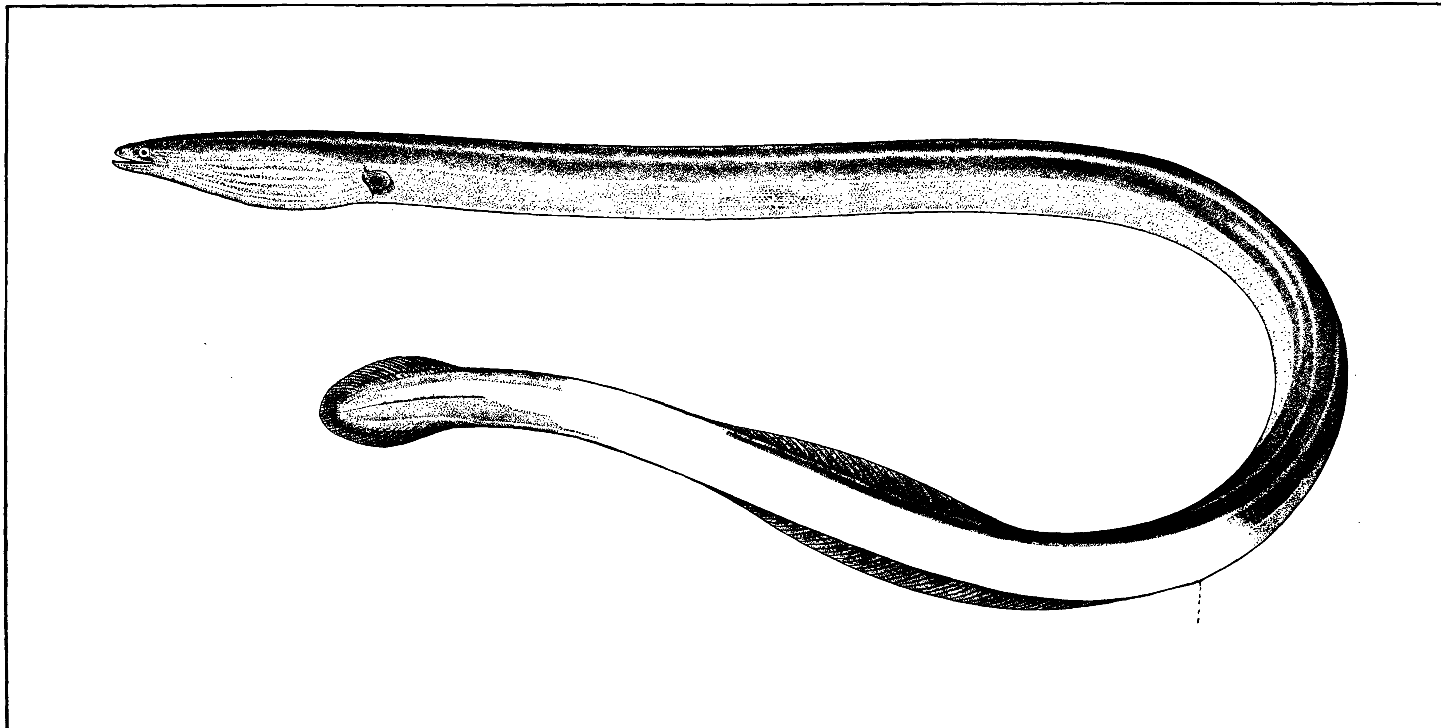

PLATE 7. MORINGUA ROBUSTA SP. NOV.

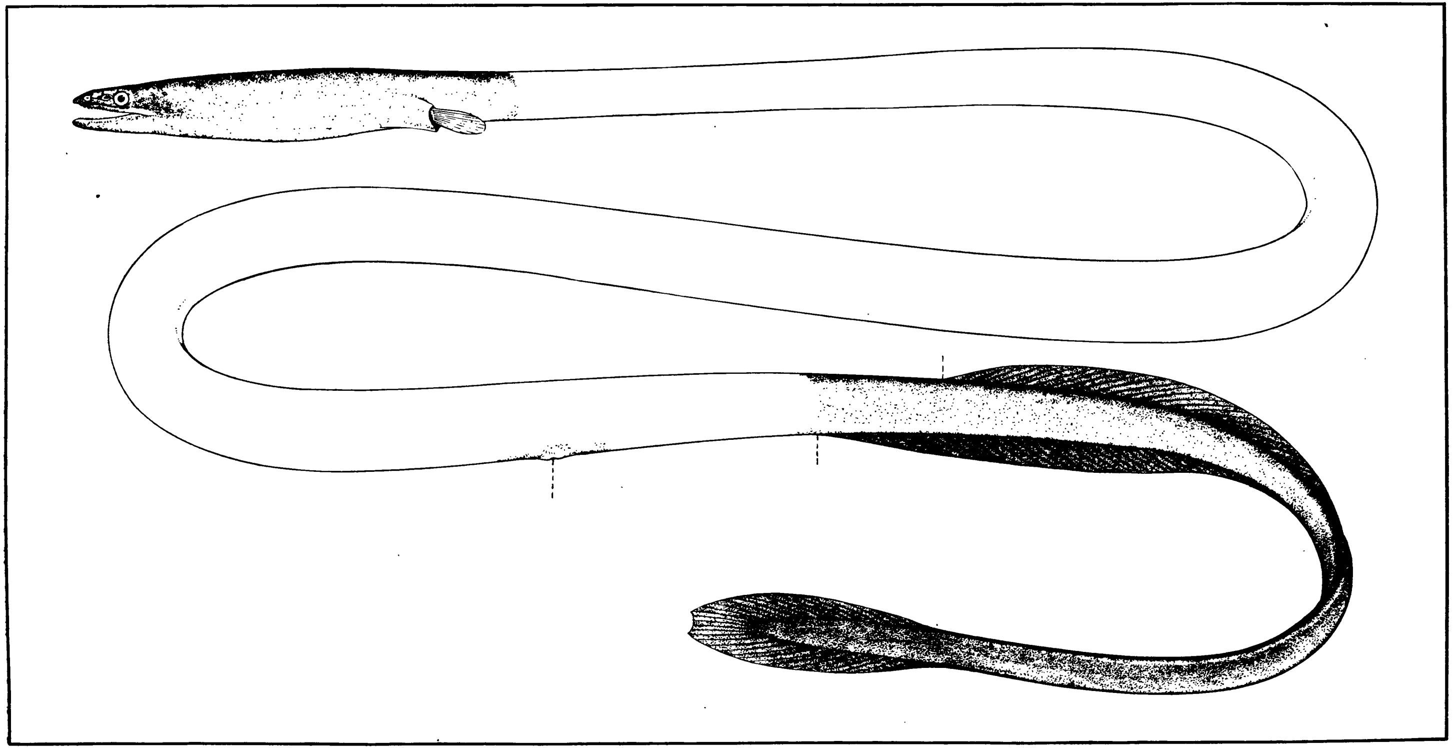

PLATE 8. MORINGUA CAGAYANA SEALE.

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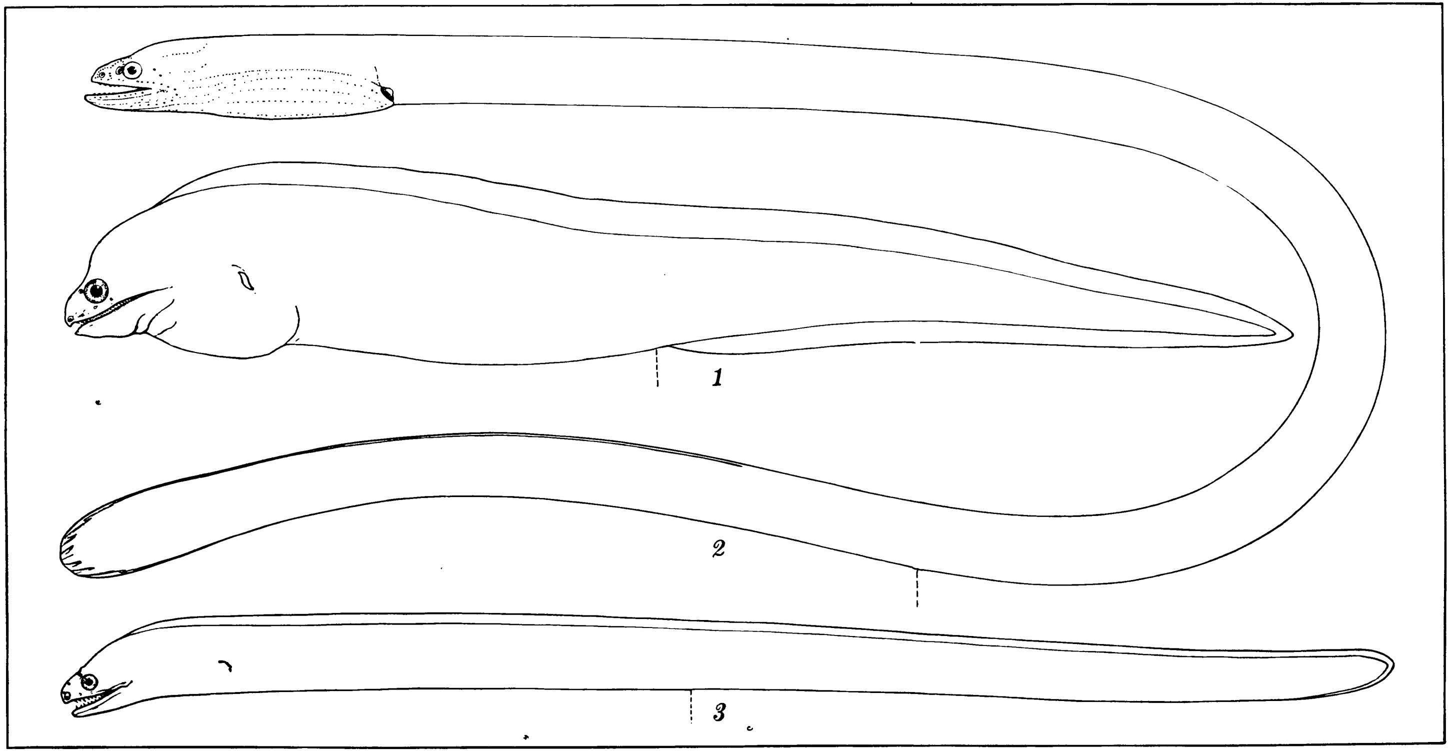

PLATE 9.

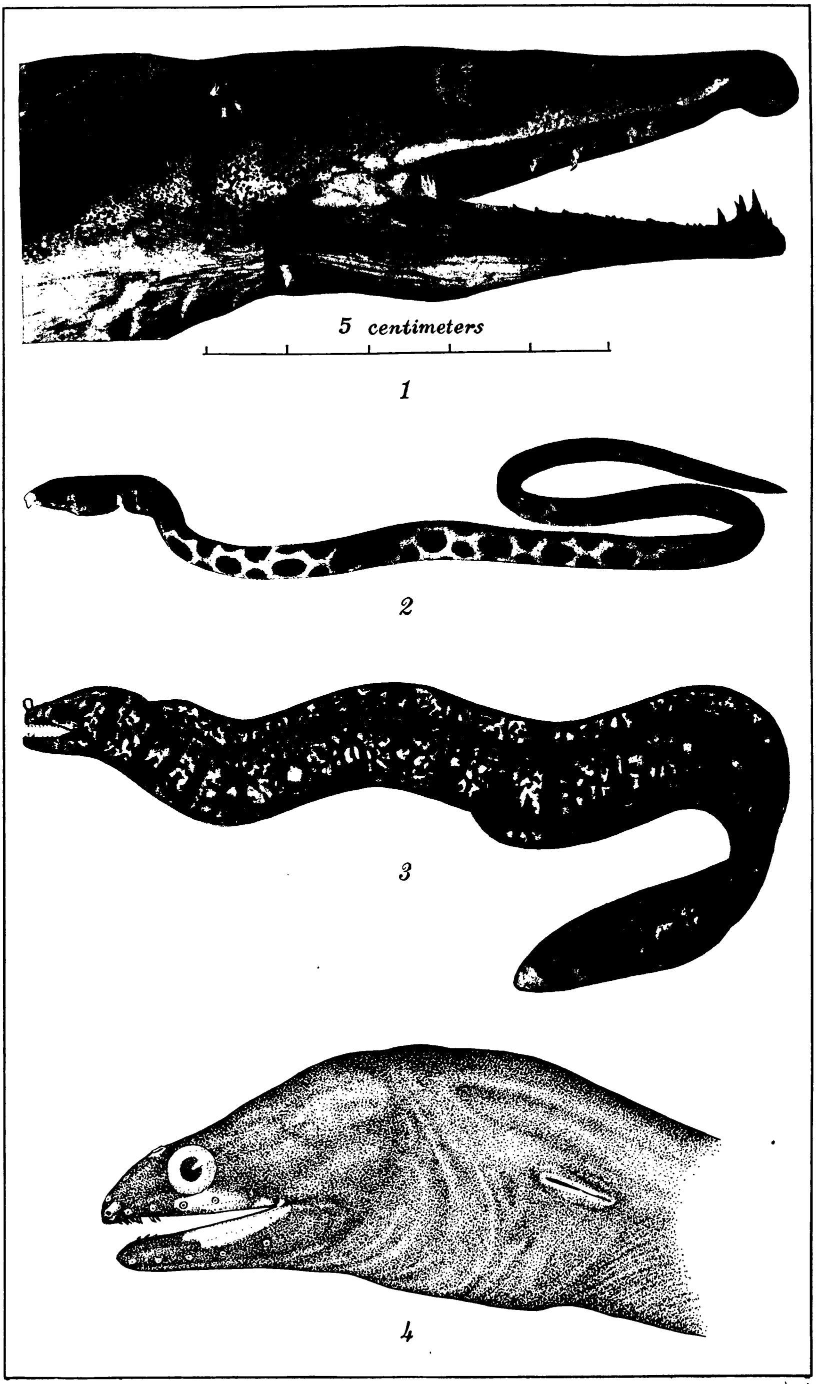

PLATE 10.

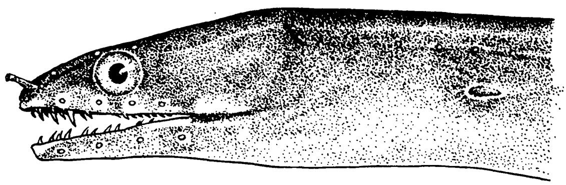

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PLATE 11.

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THE PHILIPPINE JOURNAL OF SCIENCE

VOL. 23 SEPTEMBER, 1923 No. 3

DIAGNOSES OF HAINAN PLANTS, II

By ELMER D. MERRILL

Director and Botanist, Bureau of Science, Manila

In the first paper of this series, published in 1922,[1] thirty-seven presumably new species were described. The present paper contains the descriptions of fifty-two additional forms which, like those in the first paper, are for the most part based on collections made by Mr. F. A. McClure, of the Canton Christian College. Mr. McClure's first trip to Hainan was made in September to December, 1921, and his second one in March to May, 1922. Most of the species described in the present paper were collected on the second trip.

Mr. McClure[2] has given a very interesting account of his work in Hainan, to which the reader is referred for details regarding the country and its vegetation. On both trips collections were made on Ng Chi Leng (Five Finger Mountain). This is the highest peak in Hainan, having an altitude of about 1,900 meters. The first attempt, in December, 1921, to reach the summit failed, but the goal was attained on April 30, 1922; Mr. McClure's party was the first to reach the top.

In connection with the work of identifying Mr. McClure's botanical collections, I have prepared a manuscript enumeration of Hainan plants. Previous to Mr. McClure's explorations in Hainan, but about three hundred seventy species had been definitely recorded from the island in botanical literature. His

[1] Philip. Journ. Sci. 21 (1922) 337–355.

[2] McClure, F. A., Notes on the island of Hainan, Lingnaam Agr. Rev. 1 (1922) 66–79, *t. 1–6*, map.

first collections, supplemented by material secured by other collectors, brought the number of species up to about one thousand twenty-five, while his second and more-extensive collections have increased the list to approximately one thousand three hundred seventy-five species, including the ferns and fern allies. Future explorations will unquestionably greatly increase this list.

It is impracticable here to enumerate all the species now known to occur in Hainan that are new to the Chinese flora. The value of the collections, aside from the numerous new species represented, may be estimated by the fact that one family, Ochnaceae, has been added to the Chinese list, as well as the following genera: *Arthropteris, Scleroglossum, Mapania, Arenga, Plagiostachys, Hedyosmum, Mitrephora, Polyosma, Ellipanthus, Luvunga, Heynea, Azadirachta, Xanthophyllum, Cleistanthus, Trewia, Ostodes, Gonocaryum, Arytera, Xerospermum, Mischocarpus, Ochna, Taraktogenos, Decaspermum, Rhynchosia, Epigynum, Kopsia, Fagraea, Rhynchotechum, Litosanthes,* and *Erechtites.* The genus *Tsoongia* of the Verbenaceae is described as new. One of the most remarkable finds is a representative of the genus *Hedyosmum,* of the Chloranthaceae, all other representatives of the genus being confined to tropical America.

LILIACEAE

PARIS HAINANENSIS sp. nov.

Herba erecta; foliis 6 vel 7, verticillatis, membranaceis, olivaceis, nitidis, glabris, obovatis ad oblongo-obovatis, usque ad 23 cm longis et 14 cm latis, apice breviter abrupte acuminatis, basi obtusis ad subacutis, 5-plinerviis, leviter inaequilateralibus vel aequilateralibus; petiolo 6 ad 7 cm longo; floribus longe pedunculatis; sepalis 6, lanceolatis, acuminatis, viridis, in siccitate subolivaceis, aequalibus, membranaceis, circiter 5 cm longis, 1.5 cm latis, utrinque subaequaliter angustatis, reticulatis; petalis 6, filiformibus, usque ad 10 cm longis, haud 1 mm latis; staminibus circiter 24, filamentis circiter 12 mm longis, antheris linearis, acuminatis, circiter 2 cm longis.

Ng Chi Leng and Ka La to Ta Hon, *McClure 9347* (type), *9213,* April 20 and 21, 1922, on moist rock faces in ravines and on forested slopes. Local name: *Tsat ip yat chi fa.*

A species belonging in the group with *Paris polyphylla* Sm., but, as variable as that species is, I do not see how the present form can correctly be referred to it. The sepals and petals are green, the stamens green and maroon, and the pistil is purple.

The underground stems are gathered for use for medicinal purposes.

MARANTACEAE

PHRYNIUM OLIGANTHUM sp. nov.

Herba circiter 1 m alta, glabra; foliis longe petiolatis, lamina chartacea, elliptica ad oblongo-elliptica, 30 ad 40 cm longa, 13 ad 17 cm lata, breviter acute acuminata, basi subrotundata; capitula oblonga, 5 ad 8 cm longa, 2.5 ad 3 cm diametro, immediate e vagina egrediens folio solitario comitata; bracteis glabris, exterioribus ellipticis, usque ad 4.5 cm longis et 3 cm latis, late rotundatis vel brevissime apiculato-acuminatis.

Ng Chi Leng, *McClure 9340, 9602* (type), April 20 and May 14, 1922, on forested slopes. Local name: *Chung ip* or *tung ip*.

The fugacious flowers are so badly preserved that no dissection is possible. They are described as yellow. The portion of the petiole above the insertion of the inflorescence attains a length of about 25 cm, the sheathing part being about 7 cm long and nearly 3 cm wide when spread. The species is manifestly allied to *Phrynium thorelii* Gagnep. of Indo-China, from which it is distinguished by its glabrous bracts.

FAGACEAE

QUERCUS HAINANENSIS sp. nov. § *Pasania*.

Arbor 5 ad 7 m alta, ramulis inflorescentiisque dense cinereo-pubescentibus, ramis teretibus, glabris; foliis chartaceis vel subcoriaceis, integris, oblongo-ellipticis, olivaceis, nitidis, 8 ad 14 cm longis, 3.5 ad 6 cm latis, perspicue acuminatis, basi acutis, supra glabris, costa nervisque impressis, subtus ad costa leviter pubescentibus glabrescentibus, nervis utrinque 15 ad 20, valde perspicuis, reticulis tenuibus, subparallelis; stipulis lineari-lanceolatis, circiter 4 mm longis; petiolo 1 cm longo, pubescente; spicis erectis, pedunculatis, 8 ad 11 cm longis, sub anthesin 6 mm diametro, floribus ♂ numerosis, confertis, ♀ paucis, dense pubescentibus; infructescentiis brevibus, spiciformibus, circiter 4 cm longis, fructibus junioribus plerumque binis vel trinis, circiter 1.5 cm diametro; cupulis hemisphaericis, crassis, cinereo-pubescentibus, squamis numerosis, lanceolatis, crassis, inflexis, 2 ad 3 mm longis; glandibus omnino immersis, apice truncato-convexis, junioribus cinereo-pubescentibus.

Ka La, Yik Tsok Mau, Ta Hon, and Sai Ching, *McClure 9764* (type), *9255, 9758, 9202*, April and May, 1922. On forested

slopes, in ravines, and along streams. Local names: *Shek tap shu, fu chui, fui kwoh,* and *chui shue.*

The type number presents immature fruits, the other numbers flowers only. The species is allied to *Quercus uvariifolia* Hance, from which it differs in numerous characters, notably in its nearly glabrous, fewer-nerved leaves, and like Hance's species belongs in the group with *Quercus cornea* Lour. It is probably more closely allied to the latter than to Hance's species, but can be at once distinguished by its entire leaves; however, in the larger leaves there are occasionally a few obscure teeth near the apices.

MENISPERMACEAE

CYCLEA HAINANENSIS sp. nov.

Frutex scandens, ramis ramulisque glabris; foliis ovatis vel triangulari-ovatis, chartaceis, olivaceis, circiter 11 cm longis et 8 cm latis, tenuiter acute acuminatis, basi late truncatis, vix cordatis, angulis late rotundatis, angustissime peltatis, 7-nerviis, nervis reticulisque subtus perspicuis et leviter ciliatis; petiolo 4 cm longo; paniculis ♀ caulinis, anguste pyramidatis, e basi ramosis, circiter 7 cm longis, ferrugineo-hirsutis, ramis inferioribus circiter 7 cm longis, patulis; floribus numerosis, subconfertis, bracteis anguste lanceolatis, hirsutis, 1 mm longis; sepalis 2, orbicularis, carnosis, glabris, 1 ad 1.2 mm diametro; petalis 0; ovarium glabrum.

Yik Tsok Mau, *McClure 9688,* May 18, 1922, on trees in forested ravines, the flowers white.

A species apparently most closely allied to *Cyclea polypetala* Dunn, but is distinguished by its smaller leaves, with truncate, scarcely cordate bases, glabrous branches, and smaller panicles.

MAGNOLIACEAE

KADSURA HAINANENSIS sp. nov.

Frutex scandens, glaber, ramis ramulisque teretibus, purpureis; foliis coriaceis, oblongo-ovatis ad oblongis, 8 ad 12 cm longis, 3 ad 5 cm latis, sursum angustatis, acutis vel obtusis, basi rotundatis ad acutis, in siccitate olivaceis, nitidis, nervis utrinque circiter 8, tenuibus; petiolo 1 ad 1.5 cm longo; floribus axillaribus, solitariis, pedicellatis, pedicellis petiolo subaequantibus; sepalis exterioribus ovatis, rotundatis, 4 mm longis, interioribus ellipsoideis, 8 mm longis; petalis circiter 13, oblanceolatis, circiter 24 mm longis, 5 ad 8 mm latis, rotundatis vel obtusis, deorsum angustatis, interioribus angustioribus; stami-

nibus numerosis, filamentis 1.5 ad 2 mm longis, antheris 1 mm longis; stylis circiter 25, tenuibus, cylindraceis, 6 ad 8 mm longis.

Hainan, Yan Fa, *McClure 9542* (type), *9524a* (*? 9542a*), in thickets, May, 1922.

The specimens were originally identified as *Kadsura lanceolata* King, but an analysis of the flowers showed at once that the material represented a form remote from King's species. It is distinguished not alone by its vegetative characters and its ellipsoid buds, but also by its more-numerous, longer, differently shaped petals, and from all species in the genus by its slender elongated styles.

KADSURA OBLONGIFOLIA sp. nov.

Frutex scandens, glaber, ramis ramulisque teretibus, rubrobrunneis, ramulis elongatis, vix 1.5 mm diametro; foliis oblongis ad anguste oblongis, 4 ad 9 cm longis, 1 ad 2.5 cm latis, membranaceis vel chartaceis, integris, vel margine dentibus glandulosis paucis obscuris instructis, basi acutis, apice obtusis vel obscurissime obtuse acuminatis, nervis utrinque 6 ad 8, tenuibus, obscuris; petiolo 6 ad 10 mm longo; floribus ignotis, axillaribus, solitariis, longe pedunculatis, pedunculo sub fructu usque ad 3 cm longo; fructibus ovoideis vel ellipsoideis, usque ad 2 cm longis, circiter 1.3 cm diametro, carpellis numerosis, globosis ad subellipsoideis, circiter 4 mm longis.

Nodoa and Pat Ka Leng, *McClure 8011* (type), *7866, 7973*, November, 1922, in thickets, altitude about 250 meters.

This may be the Hainan form recorded by Gagnepain as *Kadsura lanceolata* King; but, if so, I do not see how it can be referred to King's species, from which it differs notably in its differently shaped, relatively much narrower, thinner, usually obtuse leaves; the peduncles being much longer than the petioles; and the differently shaped, smaller fruits. It is apparently nearer *K. japonica* Juss. than *K. lanceolata* King. It seems probable, from a comparison of descriptions, that the Indo-China *Kadsura lanceolata* as interpreted by Gagnepain is specifically distinct from the original Malay Peninsula form.

ANONACEAE

FISSISTIGMA (MELODORUM) MACLUREI sp. nov.

Scandens (?), ramis glabris, ramulis tenuibus, pubescentibus; foliis chartaceis, olivaceis, oblongis ad oblongo-lanceolatis, 7 ad 10 cm longis, 2.3 ad 3 cm latis, tenuiter subcaudato-acuminatis, basi rotundatis, in siccitate olivaceis, supra glabris, subtus pallid-

ioribus, ad costa nervisque leviter pubescentibus; nervis utrinque circiter 8, tenuibus, subtus elevatis, perspicuis, curvato-adscendentibus; petiolo 3 ad 4 mm longo; floribus solitariis, axillaribus, dense ferrugineo-villosis; pedicellis usque ad 7 mm longis, deorsum bracteolis ovatis 5 mm longis instructis; sepalis late ovatis, obtusis, 4 mm longis; petalis exterioribus elliptico-ovatis, crasse coriaceis, 9 mm longis, 4.5 mm latis, interioribus crassioribus, ovatis, paullo brevioribus, intus glabris; antheris 1.5 ad 2 mm longis; carpellis usque ad 10, oblongo-cylindraceis, pilosis, ut videtur 4-ovulatis, 2 mm longis; stylis crassis, stigmate integro; fructibus obovoideis ad oblongis, 2 ad 3.5 cm longis, 1.5 cm diametro, ferrugineo-puberulis.

Yik Tsok Mau, *McClure 9733,* May 19, 1922, in forested ravines. Local name: *Shan tsiu.*

This species is aparently well characterized by its rather thin, subcaudate-acuminate leaves, but its true alliances are not clear to me. It is manifestly a *Fissistigma,* although Mr. McClure's notes indicate that it is a tree 15 m high with the trunk 30 cm in diameter. There is probably some error here.

FISSISTIGMA OBTUSIFOLIUM sp. nov.

Frutex scandens, foliis subtus minute puberulis inflorescentiisque ferrugineo-pubescentibus exceptis glaber; ramis ramulisque teretibus, tenuibus, atro-purpureis; foliis chartaceis vel subcoriaceis, oblongis ad oblongo-ellipticis, 7 ad 11 cm longis, 2.5 ad 4.5 cm latis, utrinque late rotundatis, apice plerumque retusis, in siccitate pallidis, supra glabris, subtus subglaucescentibus, nervis utrinque 12 ad 14, tenuibus, subtus perspicuis; petiolo glabro, circiter 7 mm longo; inflorescentiis axillaribus, fasciculatis vel depauperato-cymosis, ferrugineo-pubescentibus; floribus longe pedicellatis, pedicellis usque ad 16 mm longis, deorsum bracteolis parvis instructis; sepalis triangulari-ovatis, acutis, pubescentibus, 1.7 mm longis; petalis exterioribus late ovatis, saltem 5 mm longis, circiter 4 mm latis, extus ferrugineo-pubescentibus, interioribus oblongis ad oblongo-ovatis, circiter 4 mm longis, 2.5 ad 3 mm latis, extus puberulis, intus glabris; carpellis circiter 15, pubescentibus, 1 mm longis, sursum angustatis; stylis angustate oblongis, subteretibus vel leviter compressis, 0.8 mm longis, stigmate glabro.

Fan Ya, *McClure 9606,* May 14, 1922, in thickets along roads.

A species well characterized by its small, fascicled or depauperate-cymose, long-pedicelled flowers and by its elliptic to

oblong-elliptic leaves which are broadly rounded at both base and apex, the apex usually retuse.

POLYALTHIA CONSANGUINEA sp. nov. § *Eupolyalthia.*

Arbor parva, 3 ad 4 m alta, ramulis dense ferrugineo-pilosis; foliis chartaceis, brevissime petiolatis, oblongis ad oblongo-lanceolatis vel oblanceolatis, 10 ad 16 cm longis, 2.5 ad 4 cm latis, glabris vel subtus ad costa leviter pilosis, in siccitate pallidis, apice acuminatis, basi angustatis, minute cordatis vel auriculato-cordatis, plerumque leviter obliquis, nervis utrinque circiter 12, subtus elevatis, perspicuis, arcuato-anastomosantibus; petiolo circiter 2 mm longo, ferrugineo-pubescente; floribus pedicellatis, solitariis, extra-axillaribus; pedicellis 1 ad 1.8 cm longis, ferrugineo-pubescentibus, deorsum bracteolis 2 vel 3 parvis instructis; sepalis triangulari-ovatis, obtusis, coriaceis, leviter pilosis, 3 mm longis; petalis coriaceis, oblongis, subaequalibus, 10 mm longis, 3.5 mm latis, obtusis vel acutis, extus leviter pubescentibus, intus glabris; antheris numerosis; carpellis oblongis, 1 mm longis, leviter pubescentibus, 2-ovulatis; stigmate capitato-obovato, leviter pubescente; fructibus subglobosis, verruculosis, glabris, 1 cm diametro, longe pedicellatis.

Sha Po Leng and Ng Chi Leng, *McClure 8192, 9323, 9508* (type), November 11, 1921, April 28 and May 9, 1922, the first in fruit, the last two in flower. In forested ravines at and above 450 meters altitude.

A species in the group with *Polyalthia obliqua* Hook. f. & Th. and apparently most closely allied to *P. corticosa* Finet & Gagnep., but the petals are entirely free, glabrous within and not pubescent on both surfaces, while the pedicels of the mature fruits are verrucose and up to 12 mm in length.

POLYALTHIA CRASSIPETALA sp. nov. § *Monoon.*

Arbor circiter 5 m alta, plus minusve ferrugineo-pilosa; ramis teretibus, glabris, lenticellatis, ramulis dense ferrugineo-pilosis; foliis brevissime petiolatis, oblongis ad oblongo-lanceolatis, chartaceis, 5 ad 7 cm longis, 1.5 ad 2.5 cm latis, in siccitate brunneo-olivaceis, opacis, supra ad costa pilosis, subtus plus minusve pilosis, apice obtuse acuminatis, basi subacutis, nervis utrinque circiter 8, tenuibus, adscendentibus; floribus axillaribus, solitariis, longe pedicellatis; pedicellis ferrugineo-pilosis, usque ad 2 cm longis, deorsum bracteis foliaceis oblongis circiter 1 cm longis instructis; sepalis oblongo-ovatis ad late lanceolatis, subcoriaceis,

acuminatis, 10 mm longis, 4 ad 5 mm latis, pilosis; petalis subaequalis, crasse coriaceis, oblongo-ovatis, obtusis, 8 ad 9 mm longis, 4.5 ad 5 mm latis, leviter pilosis, in siccitate atris; antheris numerosis, connectivo truncato; ovario piloso, 1-ovulato, stylis 0.7 mm longis, stigmate villoso.

Notia, *McClure 8976*, April 11, 1922, in thickets between dry fields. The flowers are yellow and greenish, very fragrant, and the fruits are said to be edible. Local name: *Lo yan pi.*

A species rather strongly characterized by the large bracts, borne on the lower half of the pedicels, and by its very thick petals being slightly shorter than the distinctly thinner sepals.

LAURACEAE

LITSEA LANCILIMBA sp. nov.

Arbor circiter 8 m alta, glabra (floribus ignotis), ramulis circiter 6 mm diametro, teretibus, rubro-brunneis; foliis alternis, lanceolatis, 14 ad 18 cm longis, 3.5 ad 4.5 cm latis, coriaceis, tenuiter acute acuminatis, basi cuneatis, supra pallide olivaceis, nitidis, subtus glaucescentibus, vix foveolatis, nervis utrinque circiter 12, curvato-adscendentibus, utrinque cum reticulis distinctis; petiolo 3 cm longo; umbellulis axillaribus, ut videtur paucifloris, solitariis, pedunculis sub fructu valde incrassatis, usque ad 5 mm longis; fructibus oblongo-ellipsoideis, 2.5 cm longis, 1.4 cm diametro, in siccitate atris, rugosis, calycis accrescentibus subpatelliformibus, circiter 1 cm diametro, obscure irregulariter lobatis, brunneis, nitidis, rugosis, pedicellis cylindraceis, circiter 8 mm longis et 5 mm crassis.

Ng Chi Leng, *McClure 9353*, April 29, 1922, on forested slopes, altitude about 900 meters. Local name: *Pat kok.*

A species recognizable by its lanceolate acuminate leaves which are somewhat glaucous beneath and entirely glabrous on both surfaces, as well as by its paired oblong-ellipsoid black fruits and its thick-pedicelled, somewhat saucer-shaped accrescent calyces.

LITSEA MACLUREI sp. nov.

Arbor 5 ad 8 m alta, ramulis junioribus et subtus foliis minute puberulis, glabrescentibus; foliis alternis, oblongis, coriaceis, 11 ad 18 cm longis, 3 ad 5 cm latis, breviter obtuse acuminatis vel obtusis, basi cuneatis, supra in siccitate olivaceis vel viridis, subtus glaucescentibus, obscure et nec profunde sub-foveolatis; nervis utrinque 7 vel 8, curvatis, subtus conspicuis, vix anasto-

mosantibus, reticulis subobsoletis; petiolo 1 cm longo; umbellulis axillaribus, paucis, fasciculatis, pedunculatis, pubescentibus, pedunculo 7 mm longo, bracteis involucrantibus ovatis, concavis, 4 mm longis; floribus ♂ paucis, pubescentibus, tubo 3 mm longo, lobis 2 mm longis, staminibus 9; fructibus ellipsoideis, glabris, nitidis, 2.5 cm longis, 2 cm diametro, calycis accrescentibus obconicis, 2 cm longis, crasse coriaceis, glabris, verrucosis, truncatis.

Ng Chi Leng, *McClure 9360, 9586* (type), *8658,* April and May, 1922, December, 1921, in forested ravines near the cave on the south slope of the mountain, altitude about 900 meters.

A species in the same general group as the Philippine *Litsea albayana* Vid. and strongly resembling that species, differing however notably in its much larger and differently shaped fruits and larger, accrescent calyces. It differs from *Litsea vang* H. Lecomte of Indo-China by its leaves being more or less glaucous beneath; by its much shorter petioles; by its solitary or fascicled sessile fruits; and by its accrescent calyces being grayish and verruculose, not black and smooth when dry.

SAXIFRAGACEAE

DICHROA MOLLISSIMA sp. nov.

Frutex 1.5 m altus, ramulis et subtus foliis molliter villosis, ramis ramulisque teretibus, tenuibus, ramis glabris; foliis oblongo-ellipticis, chartaceis ad submembranaceis, 10 ad 15 cm longis, 2.5 ad 3.5 cm latis, supra olivaceis, nitidis, glaberrimis, subtus pallidioribus, molliter villosis, utrinque subaequaliter angustatis, apice acute acuminatis, basi acutis, margine sursum distanter denticulatis; nervis utrinque 6 vel 7, subtus distinctis, curvatis; petiolo 1 ad 3 cm longo; inflorescentiis terminalibus, pedunculatis, circiter 7 cm longis, pubescentibus; calycis cupulatis, 1.5 mm longis, lobis subpatulis, ovatis, acutis, 1 mm longis; petalis oblongo-ovatis ad lanceolato-ovatis, acutis ad acuminatis, apice inflexis, 3.5 mm longis, glabris; filamentis 1.2 ad 2 mm longis, antheris ellipsoideis, 1 mm longis; stylis 4, crassis, 1.6 mm longis.

Ng Chi Leng, *McClure 9373,* April 29, 1922, in forested ravines above the cave on the south slope of the mountain.

A species characterized by the softly villous lower surfaces of its leaves, which is the most striking differential character between it and the allied *Dichroa febrifuga* Lour.

CONNARACEAE

ELLIPANTHUS GLABRIFOLIUS sp. nov.

Arbor circiter 8 m alta, inflorescentiis fructibusque exceptis glabra, ramis ramulisque teretibus; foliis oblongis ad oblongo-lanceolatis, coriaceis, 10 ad 14 cm longis, 3 ad 3.5 cm latis, in siccitate pallide brunneis, apice obtuse acuminatis, basi obtusis ad subrotundatis, utrinque minute subfoveolatis, nervis utrinque circiter 9, tenuibus, subtus distinctis, arcuato-anastomosantibus; petiolo 1.5 ad 1.8 cm longo; inflorescentiis in axillis superioribus vel terminalibus, brevibus, cymosis, ferrugineo-pubescentibus; folliculis densissime ferrugineo-tomentosis, circiter 2.5 cm longis et 1 cm diametro, stipitatis, apiculatis, leviter compressis, obscure falcatis, intus glabris.

Ka La, *McClure 9180,* April 20, 1922, on dry slopes apparently at low altitudes.

The genus is new to China. Apparently allied to *E. cinereus* Pierre and *E. subrufus* Pierre of Indo-China, but with differently shaped, entirely glabrous leaves.

RUTACEAE

ACRONYCHIA OLIGOPHLEBIA sp. nov.

Arbor parva, circiter 7 m alta, inflorescentiis parcissime pubescentibus exceptis glabra, ramis ramulisque teretibus, rubro-brunneis; foliis oblongo-obovatis ad oblongo-ellipticis, chartaceis, subolivaceis, nitidis, 7 ad 14 cm longis, 3.5 ad 6 cm latis, apice plerumque late rotundatis, basi acutis, nervis utrinque circiter 6, patulis, distantibus, subtus perspicuis, arcuato-anastomosantibus, reticulis laxis; petiolo 1 ad 1.7 cm longo; inflorescentiis axillaribus, circiter 8 cm longis, paucifloris; floribus 4-meris, in ramulis ultimis subumbellatim dispositis, pedicellis circiter 5 mm longis, parce adpresse pubescentibus; sepalis triangularibus, acutis, 1 mm longis, obscure pubescentibus; petalis oblongo-ovatis, acutis, 3.5 mm longis, intus obscurissime pubescentibus; filamentis 3 mm longis, glaberrimis, antheris 1.2 mm longis; ovario glabro; stigmate sessile, 4-angulato, 0.3 mm diametro.

Ng Chi Leng, *McClure 9496,* May 9, 1922, in forested ravines on the south slope of the mountain, the flowers yellow and green, fragrant.

A strongly marked species most closely allied to the Philippine *Acronychia obovata* Merr., from which it is at once distinguishable by its thinner, distantly and much fewer-nerved leaves, and shorter petioles.

CLAUSENA MONINGERAE sp. nov.

Frutex 1.5 m altus vel arbor parva, usque ad 7 m alta, partibus junioribus distincte cinereo-pubescentibus, ramis teretibus, glabrescentibus; foliis 10 ad 15 cm longis, petiolis rhachibusque pubescentibus; foliolis circiter 21, oblongis, valde obliquis, 1.5 ad 3 cm longis, 8 ad 11 mm latis, punctatis, utrinque plus minusve pubescentibus, integris, rotundatis ad obtuse acuminatis, basi perspicue inaequilateralibus, uno latere rotundatis altero multo angustioribus acutis, nervis utrinque circiter 6; paniculis terminalibus, pyramidatis, 12 ad 15 cm longis, ramis inferioribus usque ad 7 cm longis, pubescentibus; floribus 4-meris, calycis acute 4-angulatis, 1.2 mm diametro; petalis ellipticis, rotundatis, 4 mm longis, glabris; filamentis 2 mm longis, sursum angustatis, antheris ellipsoideis, 1.2 mm longis; ovario cylindrico, leviter villoso; stylis crassis, cylindraceis, 1.2 mm longis.

Tai Wan San Hui, Kingchow, and without locality, *McClure 8803, 8995* (type), *Moninger s. n.*, April, 1922, and June, 1920, in thickets along roads. Local names: *Ka wong pi, tang lung shu,* and *kai tan wong.*

The specimens were originally referred to *Clausena excavata* Burm. f., but represent a form rather remote from that species and one distinctly allied to the Formosan *C. lunulata* Hayata. It is characterized especially by its numerous, small, very oblique leaflets, and its relatively elongated filaments which are nearly twice as long as the anthers. It differs from Hayata's species in its 4-merous flowers, evidently more conspicuous indumentum, and in its fewer leaflets.

MELIACEAE

DYSOXYLUM LUKII sp. nov. § *Eudysoxylum.*

Arbor 4 ad 5 m alta, perspicue molliter pubescens; ramulis ultimis circiter 1 cm diametro, dense subferrugineo-pubescentibus; foliis alternis, distantibus, circiter 60 cm longis, petiolis rhachibusque dense pubescentibus; foliolis 9 ad 11, plerumque alternis, lanceolatis vel oblongo-lanceolatis, chartaceis, 10 ad 17 cm longis, 3 ad 4 cm latis, olivaceis, nitidis, acuminatis, basi perspicue inaequilateralibus, uno latere rotundatis altero acutis, supra, costa dense pubescens excepta, subglabris, subtus molliter villosis; nervis utrinque circiter 30, perspicuis, patulis, curvatis, ad margine arcuato-anastomosantibus; paniculis supra-axillaribus, quam foliis multo brevioribus, circiter 20 cm longis, ramosis, pubescentibus; floribus 4-meris, longe pedicellatis (pedicellis 4 mm longis, pubescentibus) ; calycis subpatelliformibus, pubes-

centibus, 2.5 mm diametro, obscure lobatis; petalis liberis, oblongis, 6.5 mm longis, 2.6 mm latis, extus pubescentibus; tubo cylindrico, 5 mm longo, 2 mm diametro, glabro, libero, leviter crenulato; antheris 8, oblongis, 1 mm longis, inclusis; discus cupulatus, crenulatus, 1 mm altus; ovario villoso; stylis 4 mm longis, deorsum villosis, sursum glabris, stigmate subcapitato.

Ka La, *McClure 9196*, April 21, 1922, on rocky stream banks.

A strongly marked species, according to C. de Candolle's arrangement falling in the group with *Dysoxylum arborescens* Miq., but not at all closely allied to it or to its associated species. It is dedicated to Luk Tak, one of the Chinese collectors who accompanied Mr. McClure on his second trip to Hainan.

EUPHORBIACEAE

ANTIDESMA MACLUREI sp. nov.

Arbor circiter 5 m alta, partibus junioribus inflorescentiisque exceptis glabra, ramis tenuibus, teretibus, glabris, cinereis, ramulis leviter puberulis vel pubescentibus; foliis lanceolatis, membranaceis, 7 ad 11 cm longis, 2 ad 3 cm latis, in siccitate pallidis, nitidis, tenuiter acute acuminatis, basi rotundatis ad subacutis, nervis utrinque circiter 7, tenuibus, distinctis, utrinque glabris vel subtus ad costa leviter pubescentibus; petiolo circiter 8 mm longo, pubescente; stipulis caducis, ignotis; inflorescentiis ♀ in axillis superioribus, solitariis, paniculatis, laxis dense subferrugineo-pubescentibus vel puberulis, usque ad 8 cm longis, ramis paucis, distantibus, patulis, inferioribus circiter 3 cm longis; floribus ♀ in ramis primariis racemose dispositis, breviter (1 mm) pedicellatis, 4-meris, calycis lobis anguste ovatis, acutis, vix 1 mm longis; bracteolis lanceolato-ovatis, acuminatis, pedicellis subaequantibus; fructibus junioribus oblongis, leviter inaequilateralibus, in siccitate pruinosis, vix rugosis, circiter 3 mm longis, acuminatis, stigmate terminale.

Ng Chi Leng, *McClure 9551*, May 13, 1922, in forests.

A species in many respects resembling *Antidesma japonicum* S. & Z. and *A. gracile* Hemsl., differing notably in its paniculate inflorescences.

CLEISTANTHUS SAICHIKII sp. nov. § *Leiopyxis*.

Frutex 3 ad 4 m altus, ramulis junioribus floribusque exceptis glaber; ramis ramulisque teretibus, tenuibus, ramulis junioribus glabris vel parce ciliatis; foliis chartaceis, laevis, utrinque nitidis, ellipticis ad ovato-ellipticis vel oblongo-ellipticis, in siccitate pallidis, 3 ad 7 cm longis, 1 ad 3.5 cm latis, perspicue sed obtuse

acuminatis, basi rotundatis ad late acutis, nervis utrinque 5 vel 6, tenuibus, obscuris, reticulis subobsoletis; floribus ♂ axillaribus, paucis, solitariis vel fasciculatis, sessilibus, circiter 6 mm diametro, sepalis glabris, ovato-lanceolatis, acuminatis, 3 mm longis; petalis orbicularis, rotundatis, glabris, 0.5 mm diametro; ovarium villosum; discus cupuliformis ovarium arcte includens.

Fan Ta, *McClure 9148,* April 18, 1922, in thickets.

This species in general closely resembles *Cleistanthus sumatranus* Muell.-Arg., *C. gracilis* Hook. f., and *C. laevis* Hook. f. and, as with these species, the flowers are for the most part borne on the ultimate branchlets in the axils of the smaller leaves. Among other characters it differs from these species in its orbicular petals. It is the first representative of the genus to be found in China, as I have elsewhere shown that *Cleistanthus monoicus* Muell.-Arg. is identical with *Bridelia tomentosa* Blume = *B. monoica* (Lour.) Merr. Sai Chik, to whom the species is dedicated, was a general assistant to Mr. McClure on his second trip to Hainan.

BUXACEAE

SARCOCOCCA EUPHLEBIA sp. nov.

Frutex usque ad 1.5 m altus, glaber, ramis teretibus, ramulis sulcato-angulatis; foliis oblongo-lanceolatis, membranaceis, nitidis, 10 ad 16 cm longis, 3 ad 6 cm latis, acuminatis, basi acutis, perspicue 3-plinerviis, integris, costa nervisque supra impressis, subtus valde perspicuis, nervis utrinque 4 vel 5, distantibus, arcuato-anastomosantibus, reticulis laxis; inflorescentiis axillaribus, quam petiolis brevioribus, paucifloris, sepalis bracteolisque lanceolatis, acuminatis, 2 ad 2.5 mm longis, leviter ciliatis; fructibus ovoideis ad subglobosis, circiter 1 cm longis, rubris, in siccitate rubro-castaneis.

Ng Chi Leng, *McClure 9589* (type), *8586,* May 14, 1922, and December 21, 1921, in forested ravines and on cliffs, altitude about 750 meters.

A species strongly characterized by its very prominently nerved leaves, the midrib and the distant nerves being more or less impressed on the upper surface and very prominent on the lower surface. The basal nerves extend toward the apex at a distance of from 6 to 10 mm from the margins of the leaves and are more or less arcuate between the ends of the lateral nerves. As variable as is *Sarcococca saligna* Muell.-Arg., I do not see how the present form can possibly be referred to it.

SAPINDACEAE

XEROSPERMUM TOPENGII sp. nov.

Arbor circiter 10 m alta, subglabra, ramis teretibus, glabris, ramulis puberulis; foliis 20 ad 25 cm longis, foliolis 5, oblongo-lanceolatis, chartaceis, 10 ad 15 cm longis, 3 ad 4 cm latis, acuminatis, basi acutis, plerumque inaequilateralibus, supra olivaceis, glabris, nitidis, subtus pallidis, subglaucescentibus, leviter pubescentibus, nervis utrinque circiter 14, subtus perspicuis, reticulis utrinque distinctis; paniculis sub fructu 10 ad 12 cm longis, plus minusve pubescentibus; floribus ignotis; fructibus ellipsoideis, 2 ad 2.5 cm longis, rotundatis, in siccitate atro-castaneis, muricatis, processibus rigidis, 2.5 ad 3.5 mm longis, rectis vel leviter curvatis, obtusis vel truncatis, sulcatis, 0.5 ad 1 mm latis, basi pyramidatis.

Ng Chi Leng, *McClure 9455*, May 5, 1922, on forested slopes on the southern side of the mountain.

This species was originally referred to *Nephelium*, but by the characters given by Radlkofer it appears better placed in *Xerospermum*. It is definitely more closely allied to *X. muricatum* Radlk., of Burma and the Malay Peninsula, than to any of the species of Indo-China, authentically named specimens of all the Indo-Chinese species being available to me for purposes of direct comparison. It differs notably from *X. muricatum* Radlk. in its long-muricate fruits, the stiff, straight or curved processes attaining a length of 3.5 mm. The genus is new to China. Local name: *Shan li chi.*

SABIACEAE

MELIOSMA BUCHANANIFOLIA sp. nov.

Arbor circiter 12 m alta, inflorescentiis subferrugineo-pubescentibus exceptis glabra; ramis teretibus, circiter 5 mm diametro, perspicue lenticillatis; foliis oblongo-oblanceolatis ad oblanceolatis, subcoriaceis, olivaceis, utrinque concoloribus nitidisque, 14 ad 20 cm longis, 4 ad 6 cm latis, acuminatis, basi cuneatis, margine integris; nervis utrinque circiter 18, perspicuis, arcuato-anastomosantibus, reticulis distinctis; petiolo circiter 2 cm longo; paniculis terminalibus et in axillis superioribus, erectis, dense multifloris, pedunculatis, usque ad 18 cm longis; floribus in ramulis ultimis racemose dispositis, confertis, breviter pedicellatis, 3 mm diametro; sepalis ovatis, obtusis, 1 mm longis, leviter pubescentibus; petalis majoribus late ovatis, 2 ad 2.5 mm longis, minoribus lanceolatis, 2 mm longis, 0.8 mm latis; filamentis

fertilibus 1 mm longis, cupulis 1 mm diametro, sterilibus 1.2 mm longis, incrassatis, truncatis, incurvatis, cristatis; ovario pubescente; stylis 1 mm longis.

Yik Tsok Mau, *McClure 9732*, May 19, 1922, in forested ravines, the flowers yellowish white. The local name is recorded as *Fa muk heung*, with the statement that the Chinese on the mainland use the bark of the tree for making incense.

The species belongs in the group with *Meliosma simplicifolia* Roxb. and strongly resembles the common forms of *Buchanania arborescens* Blume; so much so that on preliminary examination the specimen was so named. Among other characters it is distinguishable from Roxburgh's species in its larger, distinctly pedicelled flowers, pubescent ovaries, and thicker leaves.

MELIOSMA TSANGTAKII sp. nov.

Arbor circiter 20 m alta, ramulis et subtus foliis ad costa nervisque dense ciliatis, paniculis dense pubescentibus; ramis teretibus, glabris, circiter 4 mm diametro, ramulis brunneis, leviter lenticellatis; foliis simplicibus, integerrimis, oblongis ad oblongo-ellipticis vel oblongo-obovatis, coriaceis, 7 ad 12 cm longis, 3 ad 3.5 cm latis, subcaudato-acuminatis, basi cuneatis, supra glabris, nitidis, olivaceis, costa nervisque impressis, subtus pallide brunneis, perspicue ciliatis, nervis utrinque circiter 10, adscendentibus, valde perspicuis; petiolo 1.5 ad 4 cm longo, pubescente; paniculis terminalibus, erectis, 10 ad 12 cm longis, pedunculatis, dense pubescentibus, ramis inferioribus usque ad 4 cm longis, patulis vel adscendentibus; floribus numerosissimis, sessilibus, sepalis leviter pubescentibus, ovatis, 1 mm longis; petalis majoribus orbiculari-ovatis, 2 mm diametro, minoribus oblanceolatis ad spatulatis, 1.5 mm longis; filamentis fertilibus 0.8 mm longis, cupulis 0.5 mm diametro, sterilibus 1.5 mm longis, truncatis, incrassatis, cristatis, ovario glabro, stylis 1 mm longis.

Ng Chi Leng, *McClure 9438* (type), *9498*, May 4 and 9, 1922, in densely forested ravines on the south slope of the mountain.

A species strongly characterized by its prominently nerved, subcaudate-acuminate, long-petioled, coriaceous leaves which are olivaceous, shining, and with prominently impressed lateral nerves and costa on the upper surface, the lower surface being pale brownish and rather densely ciliate, especially on the conspicuous ascending nerves and on the costa. It is dedicated to Tsang Tak, one of the attachés of Mr. McClure's second expedition to Hainan.

TILIACEAE

GREWIA CHUNGII sp. nov.

Arbor 6 ad 15 m alta, partibus junioribus dense ferrugineo-pubescentibus, subtus foliis parce stellato-furfuraceis; foliis oblongis, subcoriaceis, 12 ad 17 cm longis, 3.5 ad 5.5 cm latis, basi rotundatis, 3-nerviis, apice acuminatis, margine integris vel sursum minute distanter denticulatis, supra glabris, pallide olivaceis vel brunneis; nervis utrinque circiter 5, adscendentibus, subtus perspicuis, anastomosantibus; petiolo circiter 1 cm longo; inflorescentiis paniculatis, 4 ad 6 cm longis; sepalis 9 mm longis, obtusis, dense stellato-pubescentibus, margine inflexis; petalis anguste oblongis, 4 mm longis, obtusis, glandulis basilaribus incrassatis, pubescentibus; ovario pubescente; stylis glabris, 3 mm longis, tenuibus, obscurissime 2- vel 3-lobatis, lobis angustis, glabris.

Ng Chi Leng and Ka La, *McClure 9314*, *9197* (type), April, 1922, in forested ravines along streams.

A species belonging in the group with *Grewia paniculata* Roxb., but differing from Roxburgh's species in its oblong entire or nearly entire leaves which are only slightly stellate-furfuraceous and not softly tomentose on the lower surface; its shorter panicles; and its longer sepals. The flowers are arranged in groups on the ultimate branchlets of the inflorescence and subtended by an involucre of densely pubescent bracts which vary from oblanceolate to obovate, when obovate being frequently deeply 2-lobed, the lobes somewhat divaricate. The species is dedicated to Chung Yuk Fan, one of the attachés of Mr. McClure's second expedition to Hainan.

THEACEAE

ADINANDRA HAINANENSIS sp. nov.

Frutex vel arbor parva, floribus ramulisque exceptis glabra; ramis teretibus, glabris, purpureis, ramulis junioribus adpresse pubescentibus; foliis obovatis ad obovato-ellipticis, coriaceis, nitidis, pallide olivaceis, glabris, 5 ad 7 cm longis, 2.5 ad 3.5 cm latis, abrupte acuminatis, basi cuneatis, margine minute corniculato-crenatis, corniculis incurvatis, subtus glandulosis, glandulis purpureis vel brunneis, nervis primariis utrinque circiter 10, quam secondariis paullo distinctioribus, reticulis, praesertim supra, perspicuis; petiolo circiter 5 mm longo; floribus axillaribus, solitariis, sepalis ovatis, coriaceis, acutis vel acuminatis, 7 mm longis, extus dense adpresse pubescentibus, pedicellis aequantibus.

Ng Chi Leng, *McClure 9571*, May 13, 1922, in forested ravines.

A species clearly distinct from the few forms known from China and contiguous regions, well characterized by its short petioles and its leaves being rather conspicuously glandular beneath.

EURYA CILIATA sp. nov.

Arbor circiter 10 m alta, ramulis et subtus foliis, praesertim ad costa, et fructibus dense longe ciliatis; foliis subsessilibus, lanceolatis, chartaceis, 5 ad 7 cm longis, 1 ad 2 cm latis, acuminatis, basi rotundatis, distincte inaequilateralibus, minute cordatulis, margine integris vel minute denticulatis, supra subviridis, nitidis, glabris, costa profunde impressis, subtus pallidioribus, ciliatis, costa dense ciliatis, nervis utrinque circiter 14, patulis, anastomosantibus; fructibus axillaribus, numerosis, solitariis vel fasciculatis, breviter pedunculatis, ovoideis, 4 ad 5 mm longis, dense pallide ciliatis, sepalis persistentibus ellipsoideis, rotundatis, 2 mm longis, extus pubescentibus; stylis plerumque 4, liberis, glabris, 2 mm longis.

Ng Chi Leng, *McClure 9319*, April 28, 1922, in forested ravines near the cave, south slope of the mountain.

A strongly marked species, readily recognizable by its indumentum, and especially by its ovoid fruits being densely ciliate with long pale hairs.

GUTTIFERAE

GARCINIA HAINANENSIS sp. nov. § *Discostigma*.

Arbor 10 m alta, ramis teretibus, olivaceis, in siccitate rugosis, ramulis ultimis 2 mm diametro; foliis oblongo-obovatis ad oblanceolatis, chartaceis vel subcoriaceis, in siccitate pallidis, 6 ad 10 cm longis, 2 ad 3.5 cm latis, breviter acuminatis vel acutis, basi acutis, margine distincte revolutis; nervis utrinque circiter 15, tenuibus, distinctis, sub margine anastomosantibus; inflorescentiis terminalibus, paniculatis vel racemosis, paucifloris, 5 ad 6 cm longis, floribus 4-meris; sepalis orbicularis ad ovatis, in siccitate pallidis, chartaceis, rotundatis, concavis, 2 exterioribus 6 ad 7 mm longis, 2 interioribus usque ad 10 mm longis; petalis oblongis, rotundatis, circiter 17 mm longis et 8 mm latis, in siccitate brunneis; phalangibus in floribus ♂ 4, circiter 8 mm longis; pedunculis crassis, liberis, circiter 7 mm longis; antheris numerosis, sessilibus, ellipticis, 2-locellatis, longitudinaliter dehiscentibus, 0.5 mm longis, in capitulis reniformibus 4 mm diametro dispositis; pistilli rudimento fungiforme, circiter 4 mm longo.

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Ng Chi Leng, *McClure 9457*, May 6, 1922, in forested ravines on the south slope of the mountain, the flowers greenish cream colored, slightly fragrant.

A strongly marked species, apparently not closely related to any other described form of the section *Discostigma*, well characterized by its slenderly nerved leaves, their margins distinctly revolute; its terminal, paniculate or racemose, few-flowered inflorescences; and its relatively large staminate flowers.

GARCINIA OLIGANTHA sp. nov.

Frutex 1.5 m altus, ramis ramulisque tenuibus, subolivaceis, ramis teretibus, ramulis acute angulatus, 1 mm diametro; foliis chartaceis, in siccitate pallidis, oblongo-ellipticis ad lanceolatis, 5 ad 9 cm longis, 1.5 ad 3.5 cm latis, perspicue obtuse acuminatis, basi acutis; nervis utrinque 5 vel 6, tenuibus, obscuris; petiolo 4 ad 12 mm longo; floribus ♀ axillaribus, solitariis, sessilibus vel brevissime pedicellatis; sepalis 4, inaequalibus, exterioribus orbiculari-ovatis, 2 ad 3 mm longis, interioribus ellipticis ad oblongo-ellipticis, 4 ad 5 mm longis, rotundatis; staminoidiis 12, partibus liberis 0.8 ad 1.2 mm longis, basi omnibus connatis cupula 1 mm alta formantibus; ovario 4-loculare, stigmate sessile, 2 mm diametro.

Ng Chi Leng, *McClure 8701*, December 1, 1921, on forested slopes, altitude about 700 meters.

A strongly marked species, well characterized by its rather thin, few-nerved, comparatively small leaves; its very slender branches and branchlets, the latter but 1 mm in diameter and sharply angled; and its sessile, solitary, pistillate flowers, the 12 staminodes being entirely united below into a cup, 1 mm high, surrounding the ovary. In its staminode characters it resembles *Garcinia hanburyi* Hook. f. and *G. gaudichaudii* Pl. & Tr., but is otherwise not closely allied to these species.

FLACOURTIACEAE

CASEARIA VILLILIMBA sp. nov.

Arbor parva, 4 ad 7 m alta, ramulis et subtus foliis molliter pubescentibus; foliis oblongo-ellipticis, chartaceis, olivaceis, 15 ad 20 cm longis, 6 ad 8 cm latis, acuminatis, basi acutis ad obtusis, margine minute denticulatis, supra glabris, subtus molliter pubescentibus, nervis utrinque circiter 9, perspicuis, curvatis, supra haud impressis, subtus paullo elevatis; petiolo 6 ad 10 mm longo; floribus fasciculatis, pedicellatis, sepalis persistentibus oblongo-ellipticis, obtusis, 3 mm longis, leviter pubescentibus,

pedicellis 4 ad 5 mm longis; fructibus oblongis, glabris, aurantiacis, in siccitate atris, 1 cm longis, obtusis, seminibus paucis.

Ng Chi Leng and Sha Po Leng, *McClure 9326* (type), *8160*, November 11, 1921, and April 28, 1922, on forested slopes and in damp ravines, altitude at and above 450 meters.

A species most closely allied to *Casearia philippinensis* Merr., from which, among other characters, it is distinguished by its differently shaped, fewer-nerved, denticulate leaves.

TARAKTOGENOS HAINANENSIS sp. nov.

Arbor circiter 6 m alta, glabra, ramis ramulisque teretibus; foliis oblongis, chartaceis vel subcoriaceis, in siccitate pallidis, nitidis, 9 ad 13 cm longis, 3 ad 5 cm latis, basi acutis, apice obtusis vel acuminatis, margine irregulariter distanterque undulato-serratis vel serrato-crenatis, nervis utrinque circiter 8, adscendentibus, tenuibus; petiolo 1 ad 1.5 cm longo; inflorescentiis in axillis superioribus subterminalibusque, brevibus, 1 ad 1.5 cm longis; floribus ♂ confertis, 4-meris; sepalis rotundatis, concavis, glabris, 4 mm diametro, submembranaceis; petalis reniformi-ovatis, 3 ad 3.5 mm latis, 2 ad 2.5 mm longis, ciliatis, squamulis crassis, ciliatis, irregulariter 4- ad 6-dentatis, quam petalis dimidio brevioribus; staminibus 12, filamentis crassis, 1 mm longis, leviter pubescentibus; antheris oblongis, 1.5 ad 2 mm longis.

Shui Mun, *McClure 9636*, May 15, 1922, on rocky stream banks.

This species is most closely allied to *Taraktogenos serrata* Pierre of Indo-China, from which it differs in its glabrous, not ferruginous-pubescent sepals, although in the present species the very young buds are sparingly pubescent. The genus is new to China.

MYRTACEAE

EUGENIA HAINANENSIS sp. nov. § *Eueugenia.*

Arbor circiter 25 m alta (fide McClure), ramulis et inflorescentiis et foliis junioribus cinereo-pubescentibus, partibus vetustioribus glabris vel subglabris; ramis brunneis, teretibus, laevis, glabris, ramulis distincte 4-angulatis, circiter 2 mm crassis; foliis oblongo-ellipticis, coriaceis, utrinque subaequaliter angustatis acutisque vel apice breviter acuminatis, 5 ad 8 cm longis, 1.5 ad 3 cm latis, supra olivaceis, nitidis, glabris vel junioribus puberulis, minutissime punctatis, subtus pallidioribus, margine minute revolutis, nervis utrinque 15 ad 20, tenuibus, obscuris, plerumque obsoletis vel subobsoletis; petiolo 7 ad 10 mm longo, puberulo; cymis axillaribus, pedunculatis, cinereo-pubes-

centibus, paucifloris, circiter 4 cm longis; floribus plerumque 5-meris, longe pedicellatis, pedicellis 10 ad 17 mm longis, bracteis binis crassis ellipticis ad spatulatis dense pubescentibus circiter 7 mm longis instructis, calycis tubo cinereo-pubescente, circiter 2 mm longo, haud vel obscurissime sulcato, lobis latissime ovatis ad reniformi-ovatis, 1 ad 1.5 mm longis; petalis ellipticis, circiter 6 mm longis, liberis, glandulosis, exterioribus extus minute pubescentibus.

Yik Tsok Mau, *McClure 9734*, May 19, 1922, in wooded ravines.

The specimen was originally identified as *Eugenia gracilenta* Hance, but presents little in common with that species and belongs in the section *Eueugenia* rather than in *Syzygium*. Specimens identified as *Eugenia gracilenta* Hance and distributed by the Hongkong Herbarium represent a *Decaspermum*.

MELASTOMATACEAE

SONERILA HAINANENSIS sp. nov.

Suffruticosa, erecta, 10 ad 20 cm alta, glabra vel superne pilis capitatis paucis instructa, caulis basi decumbens, 1.5 mm diametro, internodiis 5 ad 15 mm longis; foliis in paribus aequalibus vel subaequalibus dispositis, petiolatis, membranaceis, ellipticis ad late elliptico-ovatis, 1.5 ad 2.5 cm longis, 1 ad 2.3 cm latis, apice acutis ad rotundatis, basi rotundatis, 3-nerviis vel obscurissime 5-nerviis, reticulis obsoletis, margine distanter serratis, dentibus pilis capitatis terminantibus; petiolo 1 ad 2 cm longo; floribus terminalibus vel subterminalibus, plerumque solitariis, 3-meris, pedicellis calycibusque pilis capitatis paucis instructis, calycis cylindraceis, 5 mm longis, dentibus triangularibus, acutis, 1.5 mm longis; petalis oblongo-ellipticis, breviter acuminatis, 1 cm longis; antheris lanceolatis, breviter acuminatis, 1 cm longis.

Ng Chi Leng, *McClure 9391*, May 1, 1922, in thickets near the summit of the mountain, altitude about 1,600 meters.

A species apparently belonging in the group with *Sonerila rhombifolia* Thw., and *S. glaberrima* Arn. Among other characters it is rather strongly marked by its widely scattered capitate-glandular hairs on the younger parts of the stems, margins of the leaves, pedicels, and calyces, being otherwise wholly glabrous.

ERICACEAE

PIERIS RUBROVENIA sp. nov.

Frutex circiter 3 m altus, ramis glabris, ramulis junioribus obscure pubescentibus; foliis coriaceis, oblongis ad oblongo-

ellipticis, utrinque acutis, 4 ad 6 cm longis, 1.5 ad 2.5 cm latis, supra glabris, nitidis, subolivaceis, subtus pallidioribus, leviter pubescentibus; nervis utrinque circiter 7, subtus conspicuis, rubro-brunneis; petiolo 5 ad 7 mm longo; racemis axillaribus terminalibusque, usque ad 7 cm longis, leviter pubescentibus; floribus albidis, pedicellis 4 mm longis, leviter hirsutis; sepalis subliberis, glabris vel subglabris, oblongo-lanceolatis, 3 mm longis, acutis; corolla 7 mm longa, subcylindrica, extus parce hirsuta, lobis ovatis, subacutis, 1 mm longis; stylis 4 mm longis, glabris, filamentis minute pubescentibus, 3 mm longis, apice haud corniculatis, antheris 1.5 mm longis.

Ng Chi Leng, *McClure 9380,* May 1, 1922, in thickets in moss-covered soil at the summit of the mountain, altitude about 1,900 meters.

A species like *Pieris villosa* Hook. f. characterized by its filaments being non-corniculate. In general aspect it resembles *P. ovalifolia* D. Don, but differs not only in its staminal but also in its vegetative characters.

MYRSINACEAE

MAESA ACUMINATISSIMA sp. nov. § *Eumaesa.*

Frutex ut videtur scandens, glaber, prophyllis minutis, lanceolatis, haud cumbiformis; inflorescentiis terminalibus vel pseudo-terminalibus, bipinnnatin paniculatis, pyramidatis, 5 ad 7 cm longis, sepalis glaberrimis, haud lineatis; foliis lanceolatis, membranaceis, olivaceis, nitidis, glaberrimis, lineis nervilliformibus destitutis, 9 ad 12 cm longis, 2 ad 3 cm latis, integris vel undulatis, basi acutis, apice caudato-acuminatis, nervis utrinque 4 vel 5, distinctis, curvato-anastomosantibus, petiolo circiter 1 cm longo; paniculis e basi ramosis, ramis primariis paucis, patulis, inferioribus usque ad 3 cm longis, pedicellis tenuibus, 5 mm longis; fructibus subglobosis, circiter 3 mm diametro, haud lineatis vel punctatis, sepalis persistentibus triangularibus, acutis.

Ng Chi Leng, *McClure 8572, 9454* (type), in forested ravines, altitude about 1,400 meters.

A species perhaps belonging in the group with *Maesa pisocarpa* Blume, but, if so, then radically different from the other species placed here. Even if placed with those species characterized by lateral inflorescences, it is apparently widely different from any hitherto described form. Among the species with terminal inflorescences, the present one is characterized by its relatively small panicles which do not exceed 7 cm in

length, and is otherwise strongly characterized by its lanceolate, membranaceous, caudate-acuminate leaves and its slender elongated pedicels.

MAESA CONSANGUINEA sp. nov. § *Eumaesa*.

Frutex ut videtur scandens, glaber; prophyllis parvis, ovatis, haud cymbiformis; inflorescentiis axillaribus, solitariis, racemosis vel depauperato paniculatis, petiolo aequantibus vel paullo longioribus, sepalis haud ciliatis, haud lineatis; foliis membranaceis, oblongis ad oblongo-ovatis, olivaceis, nitidis, 7 ad 12 cm longis, 3 ad 6 cm latis, lineis nervilliformis praeditis, subcaudato-acuminatis, basi acutis ad rotundatis, margine integris vel leviter undulatis vel distanter denticulatis, nervis utrinque 5 vel 6, distinctis; petiolo 1 ad 1.5 cm longo; inflorescentiis plerumque circiter 1 cm longis, rariter 2.5 cm longis; fructibus subglobosis, breviter pedicellatis, 2.5 ad 3 mm diametro, sepalis 5, persistentibus, triangularibus, acutis.

Ng Chi Leng, *McClure 9468* (type) *9541*, May, 1922, in forested ravines on the south slope of the mountain.

A species allied to the Philippine *Maesa denticulata* Mez and to the Celebesian *M. warburgii* Mez, from both of which, among other characters, it is distinguished by its short inflorescences.

EBENACEAE

DIOSPYROS HAINANENSIS sp. nov.

Arbor 10 ad 18 m alta, subglabra, ramis teretibus, glabris, griseis, ramulis junioribus leviter hirsutis glabrescentibus; foliis coriaceis, oblongo-ellipticis, 10 ad 14 cm longis, 3.5 ad 6 cm latis, in siccitate pallidis, nitidis, obtusis ad obtuse acuminatis, basi acutis vel plerumque rotundatis, nervis utrinque circiter 9, subtus perspicuis, curvato-adscendentibus, anastomosantibus, reticulis supra obsoletis vel subobsoletis, subtus perspicuis; petiolo 1 ad 1.5 cm longo; floribus ignotis; fructibus ovoideis vel subglobosis, 3 ad 4 cm diametro, nigris, vetustioribus glabris, junioribus dense hirsutis, circiter 8-locellatis, pericarpio circiter 4 mm crasso; seminibus compressis, circiter 1.7 cm longis, albumine aequabile; calycis persistentibus crasse coriaceis, hirsutis, vetustioribus glabrescentibus, subquadratis, 2 ad 2.3 cm latis, late 4-lobatis, lobis subacutis.

Yik Tsok Mau and Ng Chi Leng, *McClure 8462* (type), *9320*, *9748*, December, 1921, and April and May, 1922, in forested ravines up to 1,200 meters altitude. Local names: *Ngau kau shue, ngau kam muk, ngau kau muk, chai pat pat.*

The vegetative characters of this species are similar to those of *Diospyros peregrina* (Gaertn.) Gürke (*D. embryopteris* Pers.), from which it can be readily distinguished by its reticulations, although prominent on the lower surface, being obsolete on the upper surface, as well as in its very different persistent calyces.

DIOSPYROS MACLUREI sp. nov.

Arbor 12 ad 15 m alta, inflorescentiis fructibusque exceptis glabra, ramis teretibus, ramulis tenuibus; foliis coriaceis vel crasse chartaceis, oblongis ad late oblongo-oblanceolatis, 8 ad 12 cm longis, 3 ad 5 cm latis, nitidis, olivaceis vel brunneis, obtuse acuminatis, basi acutis, nervis utrinque circiter 8, subtus valde perspicuis, reticulis laxis; petiolo 8 ad 10 mm longo; floribus ♀ axillaribus, ut videtur fasciculatis vel breviter racemosis; fructibus oblongo-ovoideis vel subcylindraceis, 8-locellatis, junioribus dense ferrugineo-pubescentibus, vetustioribus glabris, nigris, circiter 5 cm longis et 3 cm diametro; seminibus paucis, 3 ad 3.5 cm longis, albumine aequabile; calycis persistentibus coriaceis, sub fructu circiter 2 cm diametro, ferrugineo-pubescentibus, ut videtur glabrescentibus, 4-lobatis, lobis suborbicularis, patulis vel reflexis, late rotundatis.

Yik Tsok Mau and Ng Chi Leng, *McClure 8657*, *8463*, *9643* (type), December, 1921, and May, 1922, on forested slopes and in ravines, altitude about 650 meters.

My specimen of *8463* is sterile, although the field note accompanying it indicates that the flowers are yellowish green; *9643* presents immature fruits, and *8657* fully matured fruits, lacking however the persistent calyces. The species is well characterized by its oblong or cylindric, apparently fleshy, ultimately glabrous fruits which are black when dry, as well as by its unusually long seeds.

SYMPLOCACEAE

SYMPLOCOS LANCILIMBA sp. nov.

Arbor parva, 4 ad 5 m alta, glabra, ramis ramulisque tenuibus, glabris, ramis subpurpureis, ramulis viridis, circiter 1 mm diametro; foliis lanceolatis, chartaceis, in siccitate viridis, utrinque concoloribus, 5 ad 7 cm longis, 1.5 ad 2.5 cm latis, caudato-acuminatis, basi acutis, margine obscure distanter glanduloso-denticulatis vel integris, nervis utrinque circiter 4, distantibus, subtus perspicuis, arcuato-anastomosantibus, reticulis laxis, costa supra impressa; petiolo 2 ad 4 mm longo; inflorescentibus

axillaribus, simplicibus, racemosis, petiolo subaequantibus, plerumque 2- vel 3-floris; fructibus circiter 5 mm longis, oblongo-ovoideis, cylindraceis, glabris, pedicellis circiter 1 mm longis; bracteis et sepalis persistentibus parcissime pubescentibus.

Yik Tsok Mau, *McClure 9672*, May 18, 1922, in forested ravines.

This species in vegetative characters somewhat resembles *Symplocos modesta* Brand and *S. myrtacea* S. & Z., but differs totally from both in its very short, 2- or 3-flowered inflorescences which do not exceed the petioles in length.

SYMPLOCOS MACLUREI sp. nov.

Arbor circiter 10 m alta, ramis teretibus, glabris, ramulis inflorescentiisque densissime subferrugineo-tomentosis; foliis oblongis, 6 ad 9 cm longis, 2 ad 3 cm latis, chartaceis ad subcoriaceis, supra glabris, nitidis, viridis, subtus pallidis, subglaucescentibus, junioribus perspicue crispatulo-pilosis, vetustioribus glabris, perspicue acuminatis, basi acutis, margine subglanduloso-crenulatis, nervis utrinque 5 vel 6, subtus perspicuis, costa supra impressa; petiolo circiter 1 cm longo, piloso; spicis axillaribus, 5 ad 7 cm longis; fructibus sessilibus, oblongis, cylindraceis, 10 ad 12 mm longis, circiter 4 mm diametro, apice densissime villosis, bracteis dense villosis.

Ng Chi Leng, *McClure 9461*, May 6, 1922, in forested ravines.

A striking species, strongly characterized by the dense indumentum on the branchlets and the stout spikes; the strongly contrasted leaf surfaces, the upper being green and glabrous, except in very young leaves, the lower being pale, almost glaucous; and the conspicuous crisped indumentum which disappears in age. The cylindric fruits at full maturity are entirely glabrous except for the very densely tomentose apices, but the younger ones present the same type of indumentum in places on the sides, indicating that the very young fruits are densely tomentose.

SYMPLOCOS SCHAEFFERAE sp. nov. § *Bobua, Lodhra.*

Arbor 4 ad 5 m alta, inflorescentiis exceptis glaberrima, ramis teretibus, griseo-purpureis, ramulis flavidis, teretibus vel leviter compressis; foliis obovatis ad oblongo-obovatis, in siccitate flavidis, coriaceis, 4 ad 5 cm longis, 1.5 ad 5.5 cm latis, breviter abrupteque acuminatis, basi acutis, margine glanduloso-denticulatis, nervis utrinque circiter 6, distantibus, distinctis, perspicue et laxe arcuato-anastomosantibus, costa supra leviter impressa; petiolo 5 ad 8 mm longo; inflorescentiis axillaribus,

spicatis, simplicibus, vel circiter basi rariter ramosis, 2.5 ad 6 cm longis, adpresse pubescentibus; bracteis adpresse pubescentibus, oblongis ad lanceolatis vel subspatulatis, acuminatis, inferioribus usque ad 5 mm longis, superioribus minoribus, bracteolis late ovatis, obtusis, 2 mm longis; floribus glaberrimis, calycis tubo brevissimo, lobis elliptico-ovatis, obtusis, 2 mm longis; petalis ellipticis, rotundatis, 4 mm longis; staminibus plus minusve pentadelphis, filamentis usque ad 6 mm longis.

Wong Chuk, en route to Kachek, *McClure 9781*, June 1, 1922, along roads.

A species superficially resembling *Symplocos urceolaris* Hance and probably belonging in the same group. It differs from Hance's species in its smaller, differently shaped leaves, and its strictly spicate, not racemose inflorescences. Following Brand's arrangement of the species in this section it falls in the group with *Symplocos khasiana* Brand and *S. foliosa* Wight, from both of which it is amply distinct. The species is dedicated to Miss K. L. Schaeffer of the American Presbyterian Mission in Hainan, whose botanical collections have added several species to the Hainan list, including at least one previously undescribed form.

LOGANIACEAE

FAGRAEA CHINENSIS sp. nov.

Frutex scandens, glaber, ramulis 4 ad 5 mm diametro; foliis oblongis ad ellipticis, olivaceis, chartaceis, 7 ad 13 cm longis, 3 ad 4.5 cm latis, acuminatis, basi acutis, nervis lateralibus obsoletis vel subobsoletis; petiolo 1 ad 3 cm longo; inflorescentiis terminalibus, brevibus, 1- vel 3-floris, brevissime pedunculatis, bracteolis ovatis ad lanceolatis, acuminatis, 4 mm longis; floribus circiter 6 cm longis, breviter pedicellatis, calycis 1 ad 1.8 cm longis, lobis ovatis ad orbiculari-ovatis, rotundatis; corollae tubo circiter 3.5 cm longo, sursum ampliato, lobis obovatis, 2.5 ad 3 cm longis; fructibus ovoideis, apiculato-acuminatis, nitidis, 4 cm longis, sepalis persistentibus chartaceis, patulis.

Yik Tsok Mau and Sha Po Leng, *McClure 9724* (type), *8187*, May 19, 1922, and November 11, 1921, in forested ravines. The same species is represented by *Hongkong Herbarium 440* from Tai Hang, Hongkong, June 28, 1893.

No representative of this genus has been hitherto recorded from China, the present species manifestly belonging in the group with, and closely allied to *Fagraea obovata* Wall., from which it differs in its much thinner, differently shaped leaves, 1- to 3-flowered inflorescences, and the persistent spreading

sepals. To be compared with the Formosan *Fagraea sasakii* Hayata.

APOCYNACEAE

EPIGYNUM CHINENSE sp. nov.

Frutex scandens, partibus junioribus parcissime pubescentibus, ramis ramulisque teretibus, laevis, ramulis 1 mm diametro; foliis oblongo-ovatis, membranaceis vel subchartaceis, olivaceis, 5 ad 7 cm longis, 2 ad 4 cm latis, acutis vel leviter acuminatis, basi obtusis vel subrotundatis, nervis utrinque 4 vel 5, tenuibus, distantibus, reticulis obsoletis vel subobsoletis, supra glabris, subtus ad costa parce adpresse pubescentibus, vetustioribus glabris; petiolo 2 ad 3 mm longo, adpresse pubescente; cymis in axillis superioribus, circiter 3 cm longis, tenuiter pedunculatis, sublaxis, plus minusve adpresse pubescentibus; floribus circiter 1.8 cm longis, calycis lobis elliptico-ovatis, obtusis, ciliatis, 1.2 mm longis, eglandulosis; corollae tubo 1.5 cm longo, deorsum glabro, sursum adpresse pubescente, in medio leviter ampliato, lobis orbiculari-ovatis, inaequilateralibus, obtusis, adpresse pubescentibus, 3 mm longis; antheris oblongis, 1.5 mm longis; discus crassus, circiter 1.2 mm altus, lobatus; folliculis linearis, 8 ad 11 cm longis, obscurissime torulosis, circiter 3 mm diametro, acuminatis, seminibus anguste lanceolatis, 1 ad 1.4 cm longis.

Yik Tsok Mau, Ng Chi Leng, and Nor Tai Shee, *McClure 9710* (type), *8606,* May 18, 1922, and December, 1921, and *Hongkong Herbarium 445 Chinese collector,* July 26, 1893, distributed as *Rauwolfia.* In forested ravines, altitude about 600 meters.

The first representative of the genus to be found in China, well characterized by its small leaves and flowers. In details of its flower it agrees closely with the characters of *Epigynum,* and I think is correctly placed here.

KOPSIA LANCIBRACTEOLATA sp. nov.

Arbor circiter 6 m alta, bracteis floribusque exceptis glabra, ramis teretibus, ramulis leviter compressis, circiter 3 mm diametro; foliis oblongis ad oblongo-ellipticis, coriaceis, 9 ad 12 cm longis, 4 ad 5.5 cm latis, nitidis, utrinque concoloribus, utrinque subaequaliter angustatis, apice breviter obtuse acuminatis, basi acutis, nervis utrinque 12 ad 15, tenuibus, distinctis; petiolo 5 ad 7 mm longo; inflorescentiis (floribus exceptis) circiter 5 cm longis, pedunculatis, parce ramosis, floribus ad apice ramulorum confertis, sessilibus; bracteis confertis, lanceolatis,

acuminatis, cinereo-puberulis, 7 mm longis; calycis lobis oblongo-lanceolatis, acutis, cinereo-puberulis, 6 mm longis; corollae tubo extus glabro, intus villoso, circiter 2.5 cm longo, ad apicem leviter dilatato, lobis oblongis, circiter 1.5 cm longis; antheris lanceolatis, acuminatis, 2 mm longis, fructibus subellipsoideis, circiter 2.5 cm longis, in siccitate olivaceis, rugosis, apice rotundatis.

Ka La, *McClure 9183*, April 20, 1922, in ravines.

A species belonging in the general group with *Kopsia fruticosa* A. DC., well characterized by its lanceolate, puberulent, relatively large bracts and calyx segments, the bracts and flowers being crowded in small groups at the tips of the few primary branches of the inflorescences. The genus is new to China.

ASCLEPIADACEAE

HOYA HAINANENSIS sp. nov.

Herbacea, scandens, petalis intus parce pubescentibus exceptis glabra, ramis teretibus, 1.5 ad 2 mm diametro; foliis in siccitate chartaceis, ovato-ellipticis, penninerviis, oppositis, 6 ad 8 cm longis, 2.5 ad 4 cm latis, utrinque subaequaliter angustatis, apice acuminatis, basi acutis, nervis utrinque circiter 4, tenuibus, obscuris, subobliquis, reticulis laxis, inconspicuis; petiolo 8 ad 10 mm longo; umbellis circiter 20-floris, pedunculo circiter 2 cm longo, pedicellis tenuibus, pedunculo subaequantibus; floribus albis, 8 ad 10 mm diametro, calycis lobis oblongo-ovatis, rotundatis, 1 mm longis, glabris, petalis oblongo-ovatis, acutis vel acuminatis, intus puberulis.

Ng Chi Leng, *McClure 9759*, May, 1922, on tree trunks, south slope of the mountain.

A species belonging in the same group with and apparently closely allied to *Hoya oblongacutifolia* Cost., of Indo-China, from which it can be distinguished by its somewhat smaller flowers, the sepals rounded and glabrous, not acute and ciliate.

HOYA OBSCURINERVIA sp. nov.

Subherbacea, scandens, petalis intus exceptis glabra, ramis teretibus, 3 ad 4 mm diametro; foliis oppositis, carnosis, in siccitate coriaceis, pallidis, ellipticis ad oblongo-ellipticis, subtenuiter acuminatis, basi plerumque acutis, obscure 3- vel 5-plinerviis, circiter 10 cm longis, 4 ad 4.5 cm latis, nervis tenuibus, reticulis obsoletis; petiolo crasso, 2 ad 2.5 cm longo; umbellis circiter 25-floris, longe pedunculatis, pedunculo circiter 8 cm longo, pedicellis tenuibus, 2 ad 2.5 cm longis; floribus albis, circiter 1 cm diametro, sepalis oblongo-ovatis, subacutis,

obscurissime ciliatis; petalis intus puberulis, ovatis ad oblongo-ovatis, acutis, circiter 4.5 mm longis.

San Tsuen, near Nodoa, and Loh Hoe, *McClure 9819* (type) *Moninger 164*, April 15, 1922, and May, 1919, on trees in village commons.

The alliance of this species is clearly with *Hoya parasitica* Wall., from which it is distinguished, among other characters, by its longer petioles and distinctly larger flowers. Local name: *Ah meung hai.*

VERBENACEAE

TSOONGIA genus novum

Calyx parvus, campanulatus, extus granuloso-glandulosis, sub-bilabiato-3-dentatus. Corollae tubus elongatus, cylindraceus, sursum leviter ampliatus, fauce haud barbatus, limbus sub patens, subaequaliter 4- vel 5-lobatus, lobis late ovatis, quam tubo multo brevioribus; stamina 4, subaequalia, medio tubo affixa, leviter exserta; ovarium 2-loculare, loculis 2-ovulatis; stylus elongatus, integer, stigmate punctiforme.—Frutex erectus, leviter pubescente; foliis oppositis, integerrimis, subtus obscure punctato-glandulosis, longe petiolatis; inflorescentiis axillaribus, cymosis, laxis, paucifloris, cymis quam petiolis brevioribus; floribus parvis, aurantiacis.

TSOONGIA AXILLARIFLORA sp. nov.

Frutex erectus, 4 ad 5 m altus, ramis teretibus, subpurpureis, glabris, ramulis ferrugineo-pubescentibus; foliis membranaceis, oblongo-ovatis ad elliptico-ovatis, 6 ad 10 cm longis, 3 ad 5 cm latis, acuminatis, basi rotundatis ad subacutis, supra olivaceis vel atro-olivaceis, nitidis, glabris vel ad costa pubescentibus, subtus pallidioribus, subbrunneis, obscure puncticulatis, ad costa nervisque plus minusve pubescentibus; nervis utrinque 6 vel 7, tenuibus, subtus perspicuis, curvatis, anastomosantibus; petiolo 2 ad 3 cm longo, pubescente; cymis breviter pedunculatis, 1 ad 2 cm longis, paucifloris, bracteis linearis, vix 1 mm longis; calycis subcampanulatis, 2.5 ad 3 mm longis, 2-labiatis, labio altero ovato, rotundato, 1.5 mm lato et 1 mm longo, integro, altero bidentato, dentibus ovatis, acutis; corollae tubo 9 mm longo, extus granuloso-glanduloso, subaequaliter 4- vel 5-lobato, lobis late ovatis, rotundatis, 2 mm longis; filamentis glabris, leviter exsertis, antheris 1 mm longis.

Yik Tsok Mau, *McClure 9692,* May 18, 1922, in forested ravines. The same species is represented by *K. K. Ts'oong*

1908, from Kwangtung Province, China, localized as Yam Chow, the genus being dedicated to this collector, Professor Ts'oong (Chung) Kwan Kwong of Peking University.

Tsoongia is most closely allied to *Premna*, and is somewhat intermediate between *Vitex* and *Premna*, although distinctly closer to the former. It differs notably from *Vitex* in its subequally 4- or 5-lobed corollas which are not bilabiate, and from *Premna* in its slender, elongated corolla tubes, its strictly axillary inflorescences, its glabrous corolla throats, and its entire styles. In *Premna* the corolla tubes are short and broad, while the inflorescences are strictly terminal, except in a single species, *P. cauliflora* Stapf. In the present genus the corolla throats are not bearded, the tube being glabrous within except for a few hairs below the insertion of the filaments.

SOLANACEAE

SOLANUM DEBILISSIMUM sp. nov.

Herba prostrata, vix ramosa, usque ad 60 cm longa, caulis 1 ad 1.5 mm crassis, sulcatis, parce pilosis, nodis plerumque radicantibus; foliis membranaceis, oblongo-ovatis, utrinque sparse sed perspicue crispatulo-pilosis, plerumque in paribus inaequalibus, minoribus usque ad 2.5 cm longis et 1.5 cm latis, majoribus usque ad 6 cm longis et 2.5 cm latis, basi rotundatis, apice acutis ad acuminatis, nervis utrinque 4 ad 6, tenuibus, obscuris; floribus axillaribus, solitariis, purpureis, pedicellis usque ad 1 cm longis; calycis crispatulo-pilosis, 4 mm diametro, 10-lobatis, lobis linearis, patulis, 2 ad 3 mm longis; corollae tubo 1.5 mm longo, lobis lanceolatis, membranaceis, 6 ad 7 mm longis, acuminatis, parce ciliatis; antheris oblongo-ovatis, 3 mm longis; fructibus globosis, carnosis, laevis, glabris, rubris, circiter 6 mm diametro, seminibus paucis (circiter 6), compressis, reniformi-ovatis, 2 mm longis, obscure denseque reticulatis.

Ng Chi Leng, *McClure 9532*, May 11, 1922, along the margins of streams in forested ravines.

A species allied to *Solanum biflorum* Lour., but totally different from that species in its habit, as well as in numerous other characters.

RUBIACEAE

ARGOSTEMMA DISCOLOR sp. nov.

Herba simplex vel ramosa, 7 ad 12 cm longa, erecta vel deorsum procumbens, ramis hirsutis; foliis in paribus valde

inaequalibus, chartaceis, supra olivaceis, sparse hirsuto-spinulosis, praesertim ad costa et circiter margine, subtus pallidis, albidis vel subferrugineis, costa nervisque densissime subpapilloso-hirsutis, majoribus ellipticis, utrinque acutis vel obtusis, 1 ad 2 cm longis, 10 ad 14 cm latis, nervis utrinque circiter 5, tenuibus, distinctis, minoribus ovatis ad orbiculari-ovatis, 5 ad 8 mm longis; stipulis ovatis ad orbiculari-ovatis, 2 ad 4 mm longis, integris; floribus 5-meris, tenuiter pedicellatis, plerumque solitariis, pedicellis pilosis, circiter 2.5 cm longis; calycis tubo circiter 2.5 mm longo, adpresse piloso, lobis triangulari-ovatis, acuminatis, circiter 1.5 mm longis; petalis lanceolatis, acuminatis, 6 ad 7 mm longis; antheris 7 mm longis, lanceolatis.

Ng Chi Leng, *McClure 9408*, May 3, 1922, on moist, shaded rock faces and in fertile, shaded nooks on the south slope of the mountain.

A species very similar and closely allied to *Argostemma hookeri* King of the Malay Peninsula, differing in numerous details.

HEDYOTIS OLIGANTHA sp. nov.

Frutex erectus, circiter 30 cm altus, ramosus, ramis ramulisque teretibus, ramulis dense breviter sordide pubescentibus, circiter 1 mm diametro; foliis subellipticis, olivaceis, 1 ad 2 cm longis, 8 ad 11 mm latis, chartaceis, utrinque subaequaliter angustatis, breviter acute acuminatis, basi acutis, utrinque glabris vel subtus ad costa obscure puberulis, nervis utrinque circiter 3, tenuibus, obscuris, curvato-adscendentibus, reticulis obsoletis; petiolo circiter 2 mm longo; stipulis ovatis, pubescentibus, apice trifidis, lobis angustis, brevibus; floribus terminalibus vel in axillis superioribus, paucis, plerumque solitariis vel binis, sessilibus, circiter 15 mm longis, calycis tubo ovoideo, 2 mm longo, leviter pubescente, lobis 5, anguste lanceolatis, 3 ad 3.5 mm longis; corollae tubo cylindrico extus glabro, 8 mm longo, intus dense barbato, lobis oblongo-lanceolatis, 4 mm longis; antheris inclusis, 1.8 mm longis.

Ng Chi Leng, *McClure 9401*, May 1, 1922, in dense forests near the summit of the mountain, altitude about 1,900 meters.

A species belonging in the same general group with the Philippine *Hedyotis macgregorii* Merr., but differing from that species in numerous details, especially in its smaller, glabrous, acutely acuminate, fewer-nerved leaves; terete, not 4-angled branchlets; and very different flowers.

MORINDA TRICHOPHYLLA sp. nov.

Frutex alta scandens, perspicue villosus, ramis ramulisque teretibus, dense ferrugineo-villosis; foliis oblongis ad oblongo-ellipticis, chartaceis, 7 ad 12 cm longis, 3 ad 5 cm latis, supra olivaceis, subtus pallidioribus, supra sparse hirsutis, subtus perspicue villosis, apice subcaudato-acuminatis, basi rotundatis vel obscure cordatis, nervis utrinque 10 ad 12, subtus valde perspicuis; petiolo villoso, 6 ad 8 mm longo; stipulis tubulosis, vaginantibus, pilosis, usque ad 1 cm longis, truncatis, appendicibus binis filiformibus 5 mm longis terminatis; inflorescentiis terminalibus, capitulis (plerumque 5) 6 ad 8 mm diametro subumbellatim dispositis, pedunculis villosis, 2 ad 2.5 cm longis; calycis liberis, tubo plus minusve pubescente, 2 ad 2.5 mm longo, irregulariter 4-lobato, lobis lanceolatis ad lineari-lanceolatis, curvatis, 1 ad 4 mm longis; corolla 5 mm longa, tubo 2 mm longo, lobis crassis, valvatis, oblongo-ovatis, 2 mm longis, extus sparse pubescentibus, intus dense villosis; antheris oblongis, 1.4 mm longis.

Yik Tsok Mau, *McClure 8755* (type), *9668*, May 17 and 19, 1922, climbing in large trees in partly forested ravines.

A species strongly characterized by its indumentum and its slenderly acuminate leaves, strikingly different from all other species known to me. While in anthesis the calyces are free; still, I believe that the present species is correctly placed in *Morinda*, although fruiting material may show that some other generic disposition may be necessary.

MUSSAENDA MEMBRANIFOLIA sp. nov.

Frutex scandens, ramis ramulisque glabris, teretibus, tenuibus; foliis membranaceis, lanceolatis, olivaceis, 9 ad 15 cm longis, 2.5 ad 3.5 cm latis, utrinque subaequaliter angustatis, apice tenuiter acute subcaudato-acuminatis, basi cuneatis, utrinque, praesertim ad costa nervisque, parce adpresse breviter hirsutis, nervis utrinque circiter 9, distinctis, tenuibus, curvato-adscendentibus; stipulis bifidis, segmentis filiformibus, 3 ad 4 mm longis, parce adpresse hirsutis; inflorescentiis terminalibus, pedunculatis, laxis, plerumque 3-ramosis, floribus exceptis glabris vel subglabris, ramis patulis, tenuibus, circiter 2 cm longis; bracteis filiformibus, 5 mm longis; floribus paucis, breviter pedicellatis, bracteolis filiformibus, obscure hirsutis, circiter 3 mm longis, calycis tubo glabro, lobis filiformibus, circiter 4 mm longis, ut videtur persistentibus tubo subaequantibus, una maxima petio-

lata albida, membranacea, ovata, usque ad 3 cm longa et 2 cm lata, acuminata, utrinque ad nervis adpresse-hirsuta; corollae tubo saltem 7 mm longo, extus parcissime adpresse hirsuto, lobis cinereo-hirsutis, lanceolatis, acuminatis, saltem 4 mm longis.

Ng Chi Leng, *McClure 9316,* April 28, 1922, in forested ravines on the south slope of the mountain.

A species belonging in the group with *Mussaenda membranacea* King, of the Malay Peninsula, but certainly distinct from that imperfectly known one.

RANDIA CAUDATIFOLIA sp. nov.

Arbor glabra, circiter 10 m alta, ramis ramulisque teretibus, tenuibus, atro-brunneis, laevis; foliis lanceolatis, membranaceis ad chartaceis, in siccitate olivaceis vel castaneis, nitidis, 10 ad 15 cm longis, 2.5 ad 3.5 cm latis, basi cuneatis, apice longissime caudato-acuminatis, nervis utrinque 5 vel 6, tenuibus, distinctis, curvato-adscendentibus; petiolis 5 ad 7 mm longis; stipulis lanceolatis, tenuiter acuminatis, 3 ad 4 mm longis; cymis axillaribus vel oppositifoliis, 4 ad 5 cm longis, breviter pedunculatis, laxis, partibus junioribus obscure pubescentibus; calycis circiter 2.5 mm longis, breviter lobatis, lobis late ovatis, obtusis vel rotundatis, haud 0.5 mm longis; corollae tubo circiter 1 mm longo, lobis oblongis, junioribus 4 mm longis.

Ng Chi Leng, *McClure 9439* (type), *9564,* May 5 and 13, 1922, in forested ravines and on forested slopes on the south side of the mountain.

A species belonging in the group with and closely allied to *Randia racemosa* (Cav.) F.-Vill., to which the Chinese form currently referred to *Randia densiflora* Benth. is probably to be reduced. It is differentiated especially by its slenderly caudate-acuminate leaves, the acumen being up to 2 cm in length.

THE COMPOSITION OF PILI-NUT OIL

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INTRODUCTION

Several species of the genus *Canarium* bear edible nuts which have a fine flavor and yield a valuable oil. According to Lewkowitsch,[1] Java almond oil is obtained from the seeds of *Canarium commune,* which is a tree indigenous to the Moluccas and Malabar. It is cultivated in tropical Asia, where the seeds serve as a foodstuff in place of sweet almonds.

Canarium oleosum and *Canarium polyphyllum* also yield seeds very similar to those obtained from *Canarium commune.*

Pastrovich[2] examined the oil obtained from the seeds of *Canarium commune.* When subjected to pressure the seeds yield 56.1 per cent of oil which is pale yellow and has a pleasant taste. On standing "stearine" separates out at 15° C. The percentage of unsaponifiable matter in the oil was found to be 0.44. The fatty acids separated by the lead-salt-ether method consist of 44.6 per cent saturated acids and 55.4 per cent unsaturated acids. The saturated acids contained palmitic and stearic acids. The unsaturated acids gave no hexabromides, showing the absence of linolenic acid. The fatty acids consist approximately of 44.6 per cent palmitic and stearic acids, 43 per cent oleic acid, and 12.5 per cent linolic acid.

In the Philippines, oil obtained from the seeds of *Canarium ovatum* is known as pili-nut oil. *Canarium ovatum* is a tree which reaches a height of about 20 meters and a diameter of

[1] Lewkowitsch, J., Chemical Technology and Analysis of Oils, Fats, and Waxes 2 (1913) 382.

[2] Pastrovich, P., Chem. Zeit. 31 (1907) 782.

40 centimeters. This species is very abundant in southern Luzon. The fruits are 6 to 7 centimeters in length and consist of hard, thick-shelled triangular nuts surrounded by a small amount of pulp. This pulp, which is edible when cooked, also contains an oil that is occasionally extracted locally and used for lighting and cooking.

Pili nuts are rich in oil and when roasted have a delicious flavor. They are used in making confections and, by many, are considered superior to almonds. Pili-nut oil is light yellow, has an agreeable odor and taste, and is suitable for culinary purposes. The keeping quality of the oil is very good, as shown by the fact that a sample stored for about six months had no rancid taste or odor and the acid value was only 1.42. It is said [3] that an average tree produces about 33 kilograms of pili nuts in one year.

Brill and Agcaoili [4] analyzed the kernels of pili nuts and determined the constants of the oil. Their results showed that the kernels contain about 74 per cent of fat and that the oil has an iodine value of about 59 to 61 and a saponification value of 186 to 192.

SAMPLE

The sample of pili-nut oil used in this investigation was obtained from pili nuts purchased in one of the markets in Manila. The hard shell of the nuts was broken with a hammer. The kernels were removed and ground into a meal, which was placed in a small press and the oil separated from the oil cake. When the oil was allowed to stand a few hours a small amount of "stearine" separated out. This was removed by filtration and the clear oil stored in glass-stoppered bottles. The constants of this sample of pili-nut oil are given in Table 1.

TABLE 1.—*Constants of pili-nut oil.*

Specific gravity $\frac{30^\circ}{4^\circ}$	0.9069
Refractive index at 30°	1.4646
Iodine value (Hübl)	55.9
Saponification value	197.4
Acid value	1.42
Unsaponifiable matter (per cent)	0.19

[3] West, A. P., and Brown, W. H., Bull. Philip. Bureau Forestry 20 (1920) 114.

[4] Brill, H. C., and Agcaoili, F., Philip. Journ. Sci. § A 10 (1915) 114.

In investigating the composition of pili-nut oil the saturated and unsaturated acids, which are present as glycerides in the oil, were separated by the lead-salt-ether method.[5] The unsaturated acids were determined by means of the bromo-derivative method.[6] The saturated acids were converted into their methyl esters [7] which were fractionally distilled. The composition of the saturated acids was estimated by calculating the data obtained from the methyl esters.

SEPARATION OF SATURATED AND UNSATURATED ACIDS

The lead-salt-ether method does not give a complete separation of saturated and unsaturated acids, since the saturated acids are always contaminated by a small quantity of unsaturated acids, as shown by the iodine value of the saturated acids. The unsaturated acids are also likely to be contaminated with a small quantity of saturated acids, but this error can usually be reduced to an unappreciable amount by not washing very thoroughly with ether the lead salts of the saturated acids.

In separating the saturated and unsaturated acids by the lead-salt method the unsaponifiable matter originally present in the oil goes with the unsaturated acids.[8] The percentage of impure unsaturated acids, as determined, must therefore be corrected, not only for the small amount of unsaturated acids present in the saturated acids, but also for the unsaponifiable matter which they contain. Since pili-nut oil contained only 0.19 per cent of unsaponifiable matter (Table 1), it was not considered necessary to correct the unsaturated acids for this small percentage of unsaponifiable as this slight correction may be applied directly to the unsaturated glycerides, thus giving the same result.

The percentage of impure saturated acids separated by the lead-salt method was 51.45, and the percentage of unsaturated acids, 43.87. The iodine value of the impure saturated acids was 23.32, and of the unsaturated acids, 89.92. The percentage

[5] Lewkowitsch, J., Chemical Technology and Analysis of Oils, Fats, and Waxes 1 (1921) 556.

[6] Ibid. 1 (1921) 585.

[7] Jamieson, G. S., and Baughman, W. F., Journ. Am. Chem. Soc. 42 (1920) 1200.

[8] Lewkowitsch, J., Chemical Technology and Analysis of Oils, Fats, and Waxes 1 (1921) 584; Baughman, W. F., and Jamieson, G. S., Journ. Am. Chem. Soc. 43 (1921) 2697.

of unsaturated acids present as contamination in the impure saturated acids [9] was 13.34.

$$\frac{51.45 \times 23.32}{89.92} = 13.34$$

The percentage of pure saturated acids was 51.45 – 13.34, or 38.11. The total percentage of unsaturated acids corrected for the unsaturated acids which were present as contamination in the impure saturated acids was 43.87 + 13.34, or 57.21.

The results of separating the saturated and unsaturated acids in pili-nut oil are given in Table 2.

TABLE 2.—*Separation of saturated and unsaturated acids in pili-nut oil by the lead-salt-ether method.*

	Per cent.
Impure saturated acids (determined)	51.45
Unsaturated acids and unsaponifiable matter (determined)	43.87
Total	95.32
Iodine value (Hübl) of unsaturated acids	89.92
Iodine value (Hübl) of impure saturated acids	23.32
Unsaturated acids present in the impure saturated acids (calculated)	13.34
Saturated acids corrected for unsaturated acids (calculated)	38.11
Unsaturated acids corrected for the unsaturated acids present in the saturated acids	57.21

UNSATURATED ACIDS

The iodine value of the unsaturated acids, separated by the lead-salt method, was found to be 89.92 (Table 2). Since the iodine value of oleic acid is 90.07, the result obtained indicates that the unsaturated acids consist entirely of oleic acid. To obtain confirmatory data the unsaturated acids were determined by means of the bromo-derivative method, which is used to separate and identify the unsaturated acids that may be present.

The bromine addition products of the unsaturated acids were prepared by dissolving a portion of the unsaturated acids (2.1368 grams) in ether; the ethereal solution was cooled to a

[9] Baughman, W. F., Brauns, D., and Jamieson, G. S., Journ. Am. Chem. Soc. 42 (1920) 2398.

temperature of —10° and bromine was added slowly, after which the solution was allowed to stand about three hours at —10°. No crystals of linolenic hexabromide, which is insoluble in ether, were obtained. This indicated that pili-nut oil contained no linolenic glyceride. The ethereal solution was then treated with 10 per cent sodium thiosulphate solution, to remove the excess of bromine. This treatment was repeated, to remove the last traces of bromine, after which the separated ethereal solution was dehydrated with anhydrous sodium sulphate, filtered, and distilled to eliminate the ether. The residue was then treated with petroleum ether (boiling point, 35° to 55°) and heated (reflux) for about a half hour. The petroleum ether solution was then cooled and allowed to stand several hours. No crystals of linolic tetrabromide were obtained. The solution was concentrated, by distilling, to a volume of about 200 cubic centimeters, cooled, and allowed to stand several hours, but still the tetrabromide did not crystallize. This indicated that, if the oil contained linolic glyceride, the percentage was probably small. The petroleum ether solution was concentrated to a volume of about 100 cubic centimeters, transferred to a small distilling flask, and the petroleum ether eliminated by distilling under diminished pressure. The dry residue (3.3540 grams) was weighed and the bromine content determined by boiling about 0.1 gram with about 0.5 gram of solid silver nitrate and 30 cubic centimeters of pure concentrated nitric acid. The precipitated silver bromide was then collected on a Gooch filter. The bromine content of the residue was found to be 36.03 per cent. Since oleic dibromide contains 36.18 per cent bromine the unsaturated acids consist entirely of oleic acid. The unsaturated acids separated by the lead-salt method and corrected for the unsaturated acids, which were present as impurity in the impure saturated acids, amounted to 57.21 per cent (Table 2). This is equivalent to 59.78 per cent of oleic glyceride which, according to the analysis, is the only unsaturated glyceride present in the oil.

Since the unsaponifiable matter (0.19 per cent, Table 1) present in the oil goes with the unsaturated acids in the lead-salt separation, the percentage of oleic glyceride corrected for unsaponifiable matter is 59.78 — 0.19, or 59.59.

The data obtained by analyzing the bromo-derivatives of the unsaturated acids are given in Table 3.

TABLE 3.—*Analysis of unsaturated acids.*

Sample of unsaturated acids (grams)	2.1368
Linolenic hexabromide insoluble in ether	....
Linolic tetrabromide insoluble in petroleum ether	....
Residue (grams)	3.3540
Bromine content of residue (determined) (per cent)	36.03
Oleic acid equivalent to dibromide (grams)	2.1400
Impure oleic glyceride in oil (per cent)	59.78
Oleic glyceride corrected for unsaponifiable matter (per cent)	59.59

SATURATED ACIDS

The impure saturated acids were converted into their methyl esters by dissolving the acids in methyl alcohol and saturating the solution with dry hydrogen chloride, which was prepared by treating fused ammonium chloride with sulphuric acid and passing the gas through sulphuric acid. The mixture was then heated on a water bath (reflux) for fifteen hours, after which it was treated with water and the ester layer separated. The esters were dissolved in ether and the ethereal solution washed with sodium carbonate solution and afterwards with water. The ethereal solution was then dehydrated with anhydrous sodium sulphate, filtered, and the ether removed by distilling. The impure esters (43.8832 grams), which were yellow, were distilled under diminished pressure. A preliminary distillation at about 15 millimeters pressure was made, to obtain the pure colorless esters and eliminate the dark impurities which were formed as by-products in the esterification process. The colorless esters (39.5476 grams) were then redistilled at 15 millimeters pressure. Data on the distillation of the esters are given in Table 4.

TABLE 4.—*Distillation of the impure methyl esters of the saturated acids; pressure, 15 millimeters.*

	Grams.
First distillation:	
Esters distilled, boiling point 195 ° to 210°C	43.8832
Distillate	39.5476
Residue	4.3356
Second distillation: Esters distilled	39.5476

Fraction.	Grams.	Saponification value.	Iodine value (Hübl).	Boiling point.
				°C.
I	19.1886	204.5	15.35	195.8–198.3
II	16.4020	201.5	21.53	198.3–209.7
Residue	3.9570	....	....	....

The iodine values of the two fractions of methyl esters obtained in the second distillation (Table 4) show that these esters were contaminated with methyl oleate, since olein was found to be the only unsaturated glyceride in the oil. The percentage of unsaturated esters (methyl oleate) in each fraction of the impure esters was calculated from the iodine value. The saponification values and mean molecular weights of the esters of the saturated acids, uncontaminated with unsaturated esters, were then calculated, after which the composition of each fraction of the impure methyl esters was determined. The results are recorded in Table 5.

TABLE 5.—*Composition of methyl esters.*

Methyl esters of acids (second distillation).	Fractions.	
	I	II
	Per cent.	*Per cent.*
Oleic	17.89	25.09
Palmitic	82.11	67.45
Stearic	----------	7.46
Total	100.00	100.00

Acids, equivalent to esters.	Fractions.		Total.
	I	II	
	Grams.	*Grams.*	*Grams.*
Oleic	3.27	3.92	7.19
Palmitic	14.94	10.49	25.43
Stearic	----------	1.17	1.17

The saponification value of the saturated esters in the first fraction (Table 5) was 207.8, and the mean molecular weight, 270. Since the molecular weight of methyl palmitate is 270.3, the pure saturated esters in the first fraction consisted entirely of methyl palmitate. The saponification value of the saturated esters in the second fraction was 205.5, and the mean molecular weight, 273.1. Since the mean molecular weight is between the molecular weights of methyl palmitate (270.3) and methyl stearate (298.4), the saturated esters consist of a mixture of these two esters. Knowing the weights of the esters in each fraction (Table 4) and the composition of each fraction, the quantity of acids equivalent to the methyl esters was obtained (Table 5), after which the total percentage of saturated glycerides present in the original oil was calculated (Table 6). In making these various calculations the method adopted by Baughman and Jamieson in their investigation of Hubbard

squash-seed oil[10] was, in general, used and the following data were employed:

Molecular weight of potassium hydroxide	56.1
Iodine value of methyl oleate	85.81
Saponification value of methyl oleate	189.5

TABLE 6.—*Calculation of saturated acids to glycerides originally present in the oil.*

Acid.	Mixture of saturated acids.		Saturated acids calculated on basis of original oil.	Saturated glycerides in original oil.
	Grams.	*Per cent.*	*Per cent.*	*Per cent.*
Palmitic	25.43	95.60	36.43	38.25
Stearic	1.17	4.40	1.68	1.76
Total	26.60	100.00	38.11	40.01

As shown by the data given in Table 6, palmitin and stearin are the only saturated glycerides present in the oil.

In calculating the composition of the saturated acids the residues obtained in distilling the methyl esters were not considered. Since the esters seemed to decompose somewhat during the distillation, it was thought that the data obtained by analyzing the impure residues would not really represent the properties of the pure esters. There is, of course, a possibility that these residues contained other esters, in addition to those recorded. Considering the temperatures of the distillates and the experimental observations this would, however, appear to be unlikely.

SUMMARY

Pili-nut oil is an edible oil which has good keeping qualities and the following composition:

Constituent.	Per cent.
Oleic glyceride	59.6
Palmitic glyceride	38.2
Stearic glyceride	1.8
Unsaponifiable matter	0.2
Total	99.8

We wish to express our thanks and appreciation to Mr. Arthur F. Fischer, director of the Philippine Bureau of Forestry, for the material which he kindly supplied for this investigation and the assistance he has given.

[10] Baughman, W. F., and Jamieson, G. S., Journ. Am. Chem. Soc. 42 (1920) 156.

EFFECT OF COMPOSITION ON THE COMPLETE HYDROGENATION OF SOME PHILIPPINE OILS WITH NICKEL CATALYST

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ONE PLATE AND THREE TEXT FIGURES

INTRODUCTION

In recent years the demand for edible oils has been steadily increasing. As a result of this tendency, efforts have been made to convert oils that were formerly used in the manufacture of soaps and candles into edible oils, which are considerably more valuable. The method that has proved most successful is known as hydrogenation. The process consists in converting fatty oils, which are liquid at ordinary temperatures, into hard, solid fats. The liquid fats contain liquid unsaturated glycerides. When they are treated with hydrogen in the presence of a catalyst, these unsaturated substances are converted into solid saturated compounds. The hydrogenation process has been used successfully for making edible fats, like artificial butters (margarine) and lard substitutes, and also for preparing fats suitable for the soap and candle industries. This process will, no doubt, encourage the investigation and production of new oils that can be converted into edible products.

Hydrogenation plants have been operating for some years in various European countries and the United States, and recently one was built in Manila. According to Krebs [1] the hydrogenating vessel which is used in the technical process of hydrogenation has a capacity of from 1 to 30 barrels of oil. This is filled with oil to the specified capacity. The oil contained in the vessel is heated to the required temperature, and the catalyst,

[1] Krebs, A. W., Chemical Age 29 (1921) 315.

suspended in a small amount of oil, is pumped in. The circulating or agitating device is set in motion, and hydrogen gas then allowed to enter the oil. The progress of hydrogen absorption is ascertained by testing samples for the melting point. When the desired degree of saturation has been attained the oil is filtered through a press to eliminate the catalyst. The same catalyst is used a number of times, depending upon the quality of product desired.

A review of the literature[2] on this subject indicates that nickel is one of the best metallic catalysts and, when employed in hydrogenating oils, a concentration of about 2 per cent is commonly used. Increase in the percentage of nickel catalyst tends to increase the velocity of hydrogen absorption. The most-appropriate temperature for reducing a nickel catalyst, before using it in hydrogenating oils, is about 300°. The catalyst appears to work best when supported on some porous material like infusorial earth, which presents a large active surface of finely divided metal. The most-satisfactory temperature for hydrogenating oils is about 180°, and the velocity of hydrogenation is accelerated by introducing the hydrogen gas into the oil under pressure.

Very little has been written concerning the complete hydrogenation of vegetable oils with a nickel catalyst. Ellis mentions a few instances where oils have been almost completely hydrogenated or reduced to products which gave exceedingly low iodine values. Cotton-seed oil was reduced with a nickel catalyst by Normann and Pungs[3] until the resulting product had an iodine value of only 3.85. Norman and Hugel[4] obtained a sample of hydrogenated castor oil that had an iodine value of 4.8, and Boomer[5] reports a sample of coconut oil that showed an iodine value of 1. Olive, almond, peanut, sesame, poppy, and linseed oils were completely hydrogenated by Mannich and Thiele,[6] but they used 2 per cent palladium as a catalyst.

In view of the apparent scarcity of data on this subject we thought it might, perhaps, be of interest to hydrogenate com-

[2] Ellis, C. E., The Hydrogenation of Oils (1919); Henderson, G. G., Catalysis in Industrial Chemistry (1919); Maxted, E. B., Catalytic Hydrogenation and Reduction (1919); Rideal, E. K., and Taylor H. S., Catalysis in Theory and Practice (1919).

[3] Ellis, C. E., The Hydrogenation of Oils (1919) 201.

[4] Ibid. (1919) 284.

[5] Ibid. (1919) 290.

[6] Ibid. (1919) 310.

pletely some Philippine oils with a nickel catalyst and compare the results obtained by experiment with the theoretical results estimated from the composition of the oils. As the results obtained were satisfactory, it may be of interest to describe in detail the hydrogenation apparatus and the experimental procedure we used. In these experiments on the catalytic hydrogenation of Philippine oils we varied both the interval of time and the concentration of the catalyst.

METHOD AND APPARATUS

Although a large amount of experimental work has been done on the catalytic hydrogenation of oils, much of the literature on this subject is in the form of technical patents which give only a very brief and inadequate description of the hydrogenation process. Not a great deal has been written concerning the experimental details of simple laboratory methods of catalytic hydrogenation which would enable us to ascertain readily the comparative absorption of hydrogen by different kinds of oils.

The method employed in this investigation was similar to that generally used in hydrogenating nonvolatile oils. The oil containing the catalyst was stirred thoroughly, while hydrogen gas was passed into the agitated mixture, which was heated to a temperature of 180°.

The hydrogen gas was prepared by treating chemically pure zinc with dilute sulphuric acid. The gas was purified by passing through a Drechsel wash bottle containing dilute potassium hydroxide solution, and through another containing fairly concentrated potassium permanganate solution, after which it was passed through four cylinders containing anhydrous, granular calcium chloride, and finally into the vessel containing the mixture of oil and catalyst.

Before reduction, the catalyst consisted of a mixture of precipitated nickel carbonate and infusorial earth. It was prepared by dissolving 400 grams of recrystallized nickel nitrate in water and adding 90 grams of infusorial earth, after which a solution containing 180 grams of powdered sodium carbonate was added. The mixture was stirred thoroughly, and filtered. The residue was washed thoroughly until free from carbonate, spread out on a porous plate, and heated in an electric oven at a temperature of 80° until dry, after which the dried material was powdered and kept in a glass-stoppered bottle until ready for use. Since the composition of precipitated nickel carbonate varies somewhat according to the method of preparation, and usually

a portion is lost in manipulation, the exact nickel content of the catalyst was ascertained by analysis.

The catalyst was analyzed by decomposing it with hydrochloric acid, evaporating, and dehydrating the soluble silicates, after which they were eliminated by filtration. The nickel was then precipitated as hydroxide with sodium hydroxide solution in a large platinum dish, and weighed as oxide. The nickel content of the various catalysts prepared for this work was approximately 23 per cent.

In hydrogenating oils the concentration of the catalyst in per cent of nickel was calculated in the following manner: If the catalyst contains 23.44 per cent nickel then 4.27 grams of catalyst contains 1 gram of metallic nickel. In these experiments 100 grams of oil were used for hydrogenation. If 4.27 grams of catalyst containing 1 gram of metallic nickel were used to hydrogenate 100 grams of oil then the concentration of metallic nickel for this quantity of oil was considered to be 1 per cent. In all the experiments the concentration of the catalyst was calculated in this manner.

The catalyst was reduced in each case immediately before it was mixed with the oil. The procedure was as follows: The calculated quantity of catalyst was placed in a transparent quartz combustion tube and spread out in a long thin layer. Hydrogen gas, purified as previously stated, was passed through the tube, which was gradually heated in a combustion furnace to a temperature of about 300° (fig. 1). The exit end of the combustion tube contained a trap, *t*, which served as a receptacle for collecting the water given off during the reduction.

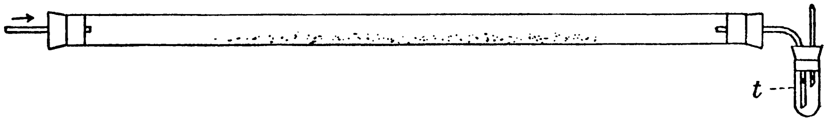

FIG. 1. Fused-quartz tube with water trap, used for preparing catalyst.

The reduction was continued for a period of about fifteen minutes, or until no more water was apparently given off. The current of hydrogen was allowed to continue flowing through the tube; which was now allowed to cool gradually to room temperature.

After reduction, the catalyst is oxidized readily when exposed to the air and consequently loses to a considerable extent its activity. In order to avoid exposing the catalyst to the air, a current of carbon dioxide gas, which was purified by passing

through silver nitrate solution and anhydrous calcium chloride, was conducted into the hydrogenating vessel above the surface of the oil contained in it. One end of the tube containing the reduced catalyst was now opened, inserted into the hydrogenation flask, and the catalyst allowed to drop quickly into the oil, after which the flow of carbon dioxide was discontinued. The tube through which the purified carbon dioxide was conducted was now removed, and the flask containing the oil and catalyst connected immediately to the stirring apparatus.

The hydrogenation flask was immersed in an oil bath, which was placed upon an electric heater. The flask was connected to a mercury gauge, *o* (fig. 2), which was used to indicate the slight pressure of gas (usually about 2 centimeters) in the apparatus. The oil bath was heated to a temperature of 180°.

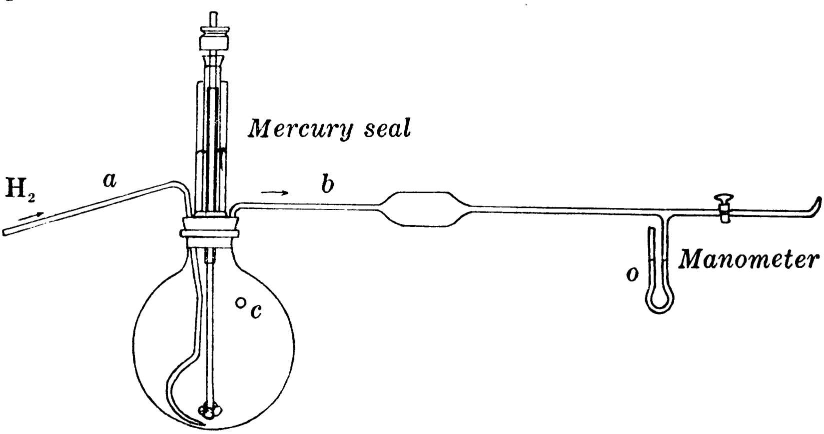

FIG. 2. Hydrogenation apparatus, showing details.

In hydrogenating an oil it is, of course, necessary to use a carefully constructed apparatus, which will allow no leakage of gas, and thus avoid explosions. The hydrogenation apparatus (fig. 2 and Plate 1) used in these experiments contained a mercury trap which allowed the mixture of oil and catalyst to be stirred during the hydrogenation. The hydrogen was admitted to the flask through the entrance tube *a*, and allowed to leave through the exit tube *b*. The hole *c*, which is about 1 centimeter in diameter, was bored into the side of the flask by means of a spear-shaped drill and enlarged with a round file.[7] In making the hole the drill was moistened with a solution of camphor dissolved in turpentine. The stopper, which was

[7] Scientific American Cyclopedia of Formulas (1918) 491.

placed very firmly in this side hole, was removed temporarily at intervals during the hydrogenation experiments, so that a pipette could be inserted into the opening and a sample of the mixture withdrawn without discontinuing the stirring or the flow of gas. The uniform sample of hydrogenated oil thus obtained was not contaminated by small quantities of previous samples; contamination occurs when the hydrogenated oil is siphoned out of the flask. In this method of hydrogenation the safety of manipulation depends upon the mercury trap, a larger diagram of which is shown in fig. 3. The stirring rod, operated by a small electric motor, passed through the tube *e*, which was inclosed in the mercury trap, *f*, *g*.

As it is somewhat difficult to filter the catalyst out of a small sample of oil which has been hardened, the samples of hydrogenated oil were treated with boiling ether. The ethereal solution containing the extracted fat was then filtered and the ether distilled off in a partial vacuum at 40°. The samples thus obtained were analyzed by determining the iodine value (Hübl) and the melting point.

In experiments requiring an unusual length of time, as in the preparation of twenty-hour samples of hydrogenated oil, it was not convenient to continue the hydrogenation and collect all the samples in one day. Therefore, the samples were collected at convenient intervals of time, after which the oil bath was removed from beneath the hydrogenation flask and the flow of gas discontinued until the following day.

In hydrogenating the oils, considerable difficulty was experienced in obtaining uniformly good results. In some experiments the catalyst worked excellently, while in others it was not so effective and, although the oil hardened, the iodine value was not greatly reduced. This was probably due to the fact that it was difficult to keep the atmosphere of the laboratory entirely free of obnoxious gases which poisoned the catalyst and decreased its activity. According to Ellis [8] mere traces of halogens or sulphur cause catalysts to lose their efficiency.

When working with a freshly prepared catalyst it is a good plan to make a preliminary test to ascertain its efficiency before proceeding with hydrogenation experiments. This may be done by using about 2 per cent nickel and hydrogenating an oil, like pili nut or cotton seed, which solidifies readily under favorable conditions and becomes a soft white solid in about an hour.

[8] Ellis, C. E., The Hydrogenation of Oils (1919) 113.

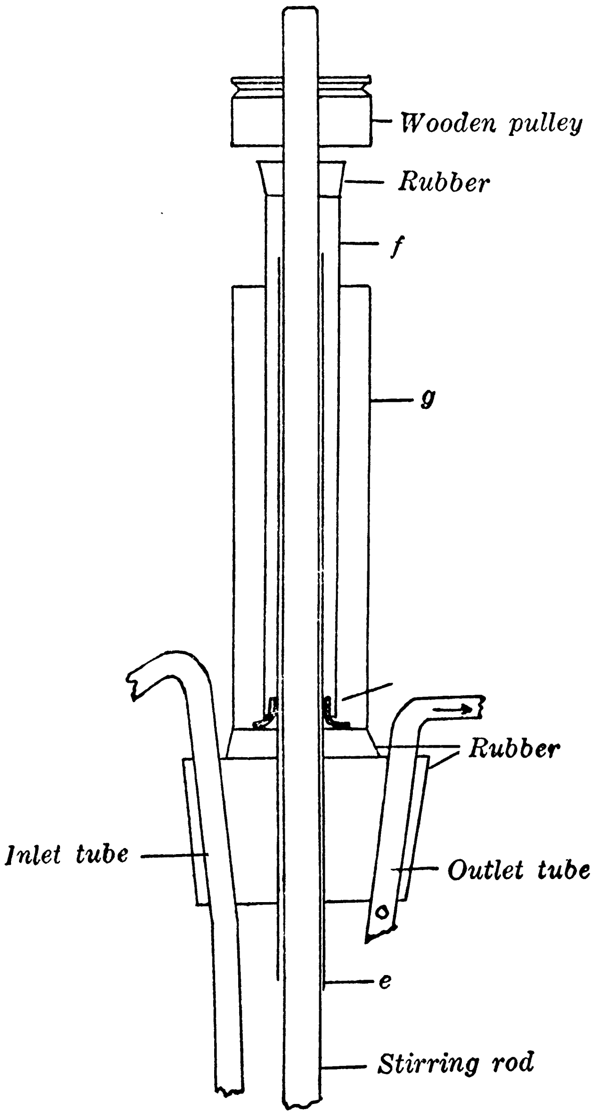

FIG. 3. Mercury trap of the hydrogenation apparatus, showing details.

SAMPLES

The samples of oils used in this investigation were obtained from fresh seeds. The seeds were shelled and the kernels ground into a meal, which was then placed in a small press and the oil separated from the oil cake. The oil was then filtered and preserved in glass-stoppered bottles, which were paraffined and kept in a dark closet until ready for use. The iodine value

of each of the oils, before hydrogenation, was determined on the fresh samples that were prepared and is recorded in the tables showing the results of hydrogenation.

RESULTS

Both drying and nondrying Philippine oils were used in this investigation. A review of the literature on these oils, giving data as to constants, general properties, and uses, as well as the growth and distribution of the Philippine trees from which they are obtained, is given by West and Brown.[9]

In these experiments the concentration of catalyst and time of hydrogenation were varied and, consequently, the results obtained show the effects of hydrogenation under various conditions.

LUMBANG OIL

Lumbang (candle-nut) oil is obtained from the nuts of *Aleurites moluccana,* which is a large tree reaching a diameter of 80 to 160 centimeters. It is used in the manufacture of paints and varnishes. The constants and the general properties of lumbang oil have been determined by various investigators.[10]

The results show that lumbang is a drying oil characterized by high iodine and saponification values.

The composition[11] of lumbang oil has been determined by means of the lead-salt-ether and bromo-derivative methods. The results (Table 1) show that lumbang oil contains the glycerides of linolenic, linolic, and oleic acids and therefore has a composition quite similar to linseed oil.

TABLE 1.—*Composition of lumbang oil.*

Constituent.	Per cent.
Linolenic glyceride	6.56
Linolic glyceride	33.48
Oleic glyceride	56.98
Glycerides of solid acids	2.85
Total	99.87

[9] West, A. P., and Brown, W. H., Bull. Philip. Bureau Forestry 20 (1920).

[10] Richmond, G. F., and Rosario, M. V. del, Philip. Journ. Sci. § A 2 (1917) 439; Wilcox E. V., and Thompson, A. R., Press Bull. Hawaii Agr. Exp. Station 39 (1913); Brill, H. C., and Agcaoili, F., Philip. Journ. Sci. § A 10 (1915) 111; Aguilar, R. H., Philip. Journ. Sci. § A 12 (1917) 235 and 14 (1919) 275; West, A. P., and Brown, W. H., Bull. Philip. Bureau Forestry 20 (1920) 121; West, A. P., and Montes, Z., Philip. Journ. Sci. 18 (1921) 619.

[11] West, A. P., and Montes, Z., Philip. Journ. Sci. 18 (1921) 630.

West and Smith made various commercial products, such as paints, varnishes, putties, soaps, and printing inks, from lumbang and linseed oils under identical conditions.[12] Their results show that as a drying oil lumbang appears to be just as good as linseed, and either oil can be used as an efficient substitute for the other.

TABLE 2.—*Hydrogenation of lumbang oil.*[a]

Time of hydrogenation.	Nickel.					
	0.5 per cent.		1 per cent.		3 per cent.	
	Iodine value, Hübl.	Melting point.	Iodine value, Hübl.	Melting point.	Iodine value, Hübl.	Melting point.
Hours.		°C.		°C.		°C.
1	135.0	[b]	121.9	[b]	120.25	[b]
3	96.16	[c]	91.03	[d]	89.45	[e]
5	80.70	[f]	77.60	[f]	75.05	[f]
7	57.03	42–63	51.45	42–60	58.25	49–56.5
10	38.94	52–63.5	23.64	60–67	32.32	58–64.5
15	27.93	60–70	8.85	60–68.5	7.55	67–69.5
20	----------	----------	1.65	66–70	1.08	67.5–71.5

[a] The iodine value of lumbang oil before hydrogenation was 153.2.
[b] Liquid.
[c] Ten per cent solid.
[d] Fifteen per cent solid.
[e] Thirty per cent solid.
[f] Soft solid.

When oils are subjected to catalytic hydrogenation the unsaturated glycerides (linolenic, linolic, and oleic) absorb hydrogen and are gradually converted to stearin on complete reduction, while incomplete reduction leads to the formation of mixed glycerides which are partly unsaturated as shown by the iodine value of the reaction product.

The results of hydrogenating lumbang oil for various intervals of time with different concentrations of catalyst are given in Table 2. As shown by the data, lumbang oil is easily hydrogenated when reduced with an effective catalyst. For each period of hydrogenation, increase in the concentration of catalyst from 0.5 to 1 per cent of nickel gave a decrease in the iodine value and an increase in the melting point. Similar results were expected for an increase from 1 to 3 per cent in the concentration of the catalyst. Hydrogenation with 3 per cent nickel

[12] Bull. Philip. Bureau Forestry 24. In press.

gave, however, about the same results as with 1 per cent. Possibly this was due to the fact that the catalyst was not working so effectively in this particular reduction.

Lumbang oil consists almost entirely of a mixture of linolenic, linolic, and oleic glycerides. When lumbang oil is completely hydrogenated the reduction product should, theoretically, have no iodine value, and the melting point should be approximately 71.6°, which is the melting point of pure stearin. With a catalyst containing 3 per cent nickel, hydrogenation for twenty hours at practically atmospheric pressure gave a sample having a melting point of 67.5° to 71.5° and an iodine value of only 1.08. This result would seem to indicate that the hardened lumbang oil, which had the appearance of a hard, white solid, was nearly pure stearin.

The results obtained experimentally agree fairly well with the results estimated from the composition of the oil, and indicate that lumbang contains no considerable quantity of saturated glycerides of low melting point. The result of complete hydrogenation serves, therefore, as a kind of check on the composition of the oil as determined by analysis.

PILI NUT

Pili-nut oil is obtained from the nuts of *Canarium ovatum,* which is a tree reaching a height of about 20 meters and a diameter of 40 centimeters. This species is very abundant in southern Luzon. The fruits are 6 to 7 centimeters in length and consist of hard, thick-shelled, triangular nuts surrounded by a small amount of pulp. Pili nuts are rich in oil and when roasted have a delicious flavor. They are used in making confections and by many are considered superior to almonds. Pili-nut oil is light yellow, has an agreeable odor and taste, and is suitable for culinary purposes.

The composition [13] of pili-nut oil has been determined by means of the lead-ether and bromo-derivative methods. Table 3 shows that pili-nut oil consists largely of the glycerides of oleic and palmitic acids and contains also a small percentage of stearic glyceride.

[13] Composition determined by A. P. West and S. Balce, antea 269.

TABLE 3.—*Composition of pili-nut oil.*

Constituent.	Per cent.
Oleic glyceride	59.6
Palmitic glyceride	38.2
Stearic glyceride	1.8
Unsaponifiable matter	0.2
Total	99.8

TABLE 4.—*Hydrogenation of pili-nut oil.*[a]

Time of hydrogenation.	Nickel.					
	0.5 per cent.		1 per cent.		3 per cent.	
	Iodine value, Hübl.	Melting point.	Iodine value, Hübl.	Melting point.	Iodine value, Hübl.	Melting point.
Hours.		°C.		°C.		°C.
1	58.87	(b)	51.53	(b)	51.43	(b)
3	55.72	(c)	48.08	39–47	40.64	44–46
5	50.42	37–42	38.19	43–53	26.90	49–61
7	48.90	42–45	27.23	47–58	10.46	58–62
10	41.69	42–49	23.99	50–60	3.91	62–65
15	40.12	46–50	13.24	59–62	0.96	66–66.80
20	34.20	46–57	9.69	61–63	----------	--------

[a] The iodine value of pili-nut oil before hydrogenation was 60.5.
[b] Liquid.
[c] Soft solid.

The results of hydrogenating pili-nut oil for various intervals of time with different concentrations of catalyst are given in Table 4. In these experiments the catalyst was very effective and the oil absorbed hydrogen readily.

The results show that, with each concentration of catalyst, continued hydrogenation gave a gradual decrease in the iodine value of the oil and an increase in the melting point.

For each interval of hydrogenation, increase in the concentration of nickel catalyst gave an increase in the melting point of the oil and a very decided decrease in the iodine value. Hydrogenation for ten hours gave with 0.5 per cent nickel an iodine value of 41.69; with 1 per cent, 23.99; and with 3 per cent, 3.91. Hydrogenation for fifteen hours with 3 per cent nickel gave a sample having an iodine value of only 0.96 and a melting point of 66° to 66.8°. In appearance the sample was a hard white solid. Since oleic glyceride when reduced

yields stearin (melting point, 71.6°) it would seem that the melting point of this sample should have been somewhat higher. The rather low value obtained is probably due to the fact that in determining the melting point the stearin tends to dissolve in the palmitin (melting point, 63° to 65.5°), which has a lower melting point. A test experiment was performed by mixing stearin with palmitin in the same proportions as they are present in hydrogenated pili-nut oil. The melting point of the mixture was found to vary from 68° to 69°. These values are slightly higher than the results obtained with hydrogenated pili-nut oil but, as Lewkowitsch [14] has pointed out, even pure glycerides show irregularities in their melting points which are not usually given by definite chemical compounds. The results of these experiments indicate that pili-nut oil contains no saturated glycerides of low melting point and, in general, agrees in composition with the oil that showed the saturated glycerides to consist mostly of palmitin.

TABLE 5.—*Hydrogenation of pili-nut and lumbang oils.*[a]

Hydrogenation.	Nickel, 1 per cent. Iodine value, Hübl.			
	Pili-nut oil.		Lumbang oil.	
	Catalyst I.	Catalyst G.	Catalyst I.	Catalyst G.
Hours.				
1	51.53	53.12	121.9	135.55
3	48.08	44.9	91.03	118.25
5	38.19	37.0	77.6	101.05
7	27.23	27.37	51.45	92.7
10	23.99	19.21	23.64	83.6
15	13.24	----------	8.85	60.4
20	9.68	----------	1.65	32.3

[a] Before hydrogenation the iodine value of pili-nut oil was 60.5, and of lumbang, 153.2.

The results of hydrogenating pili-nut and lumbang oils with different catalysts, each of which had a concentration of 1 per cent nickel, are given in Table 5. These catalysts were made under identical conditions and were expected to give the same results. Both catalysts gave approximately the same results with pili-nut oil. With lumbang oil, however, catalyst I was considerably more effective than catalyst G. The data given for catalyst G show how the activity of the catalyst may some-

[14] Lewkowitsch, J. Chemical Technology and Analysis of Oils, Fats, and Waxes 1 (1921) 321.

times be retarded due, perhaps, to slight contaminating influences.

COCONUT OIL

Elsdon [15] determined the approximate composition of the mixed fatty acids of coconut oil by the method of alcoholysis. The results are recorded in Table 6.

TABLE 6.—*Approximate composition of the mixed fatty acids of coconut oil.*

Acid.	Per cent.
Caproic	2
Caprylic	9
Capric	10
Lauric	45
Myristic	20
Palmitic	7
Stearic	5
Oleic	2
Total	100

TABLE 7.—*Hydrogenation of coconut oil.*[a]

Time of hydrogenation.	Nickel, 3 per cent. Iodine value, Hübl.	Nickel, 3 per cent. Melting point.
Hours.		*°C.*
1	7.38	(b)
3	3.70	30–37
5	1.71	32–39
7	1.14	32–40.5
10	0.71	32–41
15	0.35	32–41
20	0.00	32–42
25	------------	32–43

[a] The iodine value of coconut oil before hydrogenation was 8.22. [b] Liquid.

Coconut oil hydrogenated with 3 per cent nickel is gradually decolorized and deodorized, but apparently does not harden very readily. Hydrogenation for fifteen hours gave a solidified sample having practically no iodine value and a melting point of 32° to 41° (Table 7). Coconut oil consists principally of the glycerol esters of lauric and myristic acids and contains also a number of other fats which are the glycerides of other fatty acids, such as caproic, caprylic, capric, and oleic (Table 6). Caproic glyceride is a liquid, while caprylic melts at 8.3°; caproic, at 31.1°; and lauric, at 45°. Although these glycerides are satu-

[15] Elsdon, G. D., Analyst 38 (1913) 8.

rated compounds they do not have high melting points, and probably for that reason coconut oil when hydrogenated is not hardened readily in the Tropics. Again the iodine value (8.22) of coconut oil is very low, which indicates that it contains only a small proportion of unsaturated glycerides and, consequently, the effect of hydrogenation is not so marked as in the case of other oils which have much higher iodine values.

PALOMARIA (BITAOG) OIL

Oil obtained from the seeds of *Calophyllum inophyllum* is known as bitaog, or palomaria de la playa. *Calophyllum inophyllum* is usually a medium-sized or large tree with a widespreading crown. It is distributed in the coast regions in various parts of the Philippines. The fruit of this species is about the size of a walnut. It has an outer fleshy part and contains a thin-shelled seed with a hard, oily kernel. The kernels yield palomaria (bitaog) oil, which is greenish yellow and has a bitter, pungent taste. According to Crevost,[16] palomaria oil contains 71.55 per cent of fatty oil and 28.45 per cent of resin. The resin is dark brown and melts at 30° to 35°. It is soluble in various organic solvents, has an iodine value of 125.2, and an acid value of 180.8.

Fenler[17] states that the fatty acids of palomaria oil consist largely of palmitic, stearic, and oleic acids.

TABLE 8.—*Hydrogenation of palomaria oil*[a]

Time of hydrogenation.	Nickel, 3 per cent.		Nickel, 5 per cent.	
	Iodine value, Hübl.	Melting point.	Iodine value, Hübl.	Melting point.
Hours.		°C.		°C.
1	83.6	(b)	81.2	(b)
3	71.65	(c)	68.35	(d)
5	67.0	(d)	57.75	37–43
10	62.3	43–50		

[a] The iodine value of palomaria oil before hydrogenation was 88.1.
[b] Liquid.
[c] Twenty per cent solid.
[d] Soft solid.

By continued hydrogenation of palomaria, the dark brown oil was gradually changed to a light yellow solid. This was the only oil used in this investigation which was not entirely de-

[16] Crevost, B., Bull. Econ. de L'Indochine, new series 8 (1906) 394.
[17] Fenler, G., Chem. Zeit. 29 (1905) 15.

colorized by hydrogenation. The data given in Table 8 show that, in hydrogenating for a definite period, increase in the percentage of nickel catalyst gave a decrease in the iodine value and an increase in the melting point. Although catalysts containing 3 and even 5 per cent nickel were employed, the oil was not reduced to a hard solid fat of high melting point. Probably this was due to the fact that the hydrogenation was not continued for a sufficient length of time and, moreover, the oil contained about 28 per cent of resin which had a very high acid value. The acid value of the oil was determined before hydrogenation and found to be 22.04.

CATALYTIC HYDROGENATION

The catalytic hydrogenation process is coming into more general use in synthetic organic chemistry where results of reduction reactions are desired. The review of the literature given by Maxted [18] and by Rideal and Taylor [19] shows the numerous applications of this process, and Lewkowitsh [20] recommends it for the preparation of unsaturated acids for identification. The old method of reducing compounds by treating them with a metal and an acid, or of dissolving them in some solvent such as alcoholic hydrochloric acid and adding a metal like zinc, is not entirely satisfactory because it is somewhat difficult to control the reaction and obtain the desired degree of reduction. Catalytic hydrogenation can be controlled to a certain extent, and in many reactions excellent results are obtained.

The hydrogenation apparatus and general laboratory procedure used in this investigation of Philippine oils gave very good results. The apparatus is easy to manipulate, and samples of the hydrogenated product having the desired degree of saturation are easily obtained. Probably this method would prove useful for certain reductions in synthetic organic chemistry where exact control of hydrogen absorption is required.

SUMMARY

A convenient and simple laboratory apparatus for the catalytic hydrogenation of oils has been described. With this appa-

[18] Maxted, E. B., Catalytic Hydrogenation and Reduction (1919).

[19] Rideal, E. K., and Taylor, H. S., Catalysis in Theory and Practice (1919).

[20] Lewkowitsch, J., Chemical Technology and Analysis of Oils, Fats, and Waxes 1 (1921) 589.

ratus the mixture of oil and catalyst can be stirred thoroughly, and uncontaminated samples of hydrogenated oil can be taken conveniently when the desired degree of absorption is attained.

The preparation of a nickel catalyst and the general procedure for laboratory hydrogenation experiments with oils have been described in detail.

The following Philippine oils were solidified: Lumbang, pili nut, coconut, and palomaria. The data obtained show that the apparatus employed and the experimental procedure followed gave excellent results under favorable conditions.

Lumbang oil was reduced to a hard solid which had an iodine value of 1.08 and a melting point of 67.5° to 71.5°. These results are in agreement with the fact that lumbang oil is composed almost entirely of linolenic, linolic, and oleic glycerides, all of which when completely reduced should, theoretically, be converted into stearin (melting point, 71.5°).

Pili-nut oil when hardened had an iodine value of 0.76 and a melting point of 66° to 66.8°. The results indicated that pili-nut oil, like lumbang, has no saturated glycerides of low melting point.

Coconut oil when completely hydrogenated had a melting point of 32° to 43° and no iodine value. The low melting point of the hardened oil is apparently due to the fact that coconut oil contains saturated glycerides which have low melting points.

Palomaria oil when hardened was not reduced to a hard solid of high melting point and low iodine value. Probably this was due to the high acidity of the oil.

Oils hydrogenated with catalysts containing different percentages of nickel showed that, for a definite period of absorption, an increase in the concentration of nickel gave a decrease in the iodine value and an increase in the melting point.

This method of catalytic hydrogenation may prove useful, not only for ascertaining readily the comparative absorption of hydrogen by different kinds of oils, but also for making certain reductions in synthetic organic chemistry.

We wish to express our thanks and appreciation to Mr. Arthur F. Fischer, director of the Philippine Bureau of Forestry, for the material used in this investigation and the assistance he has kindly given.

ILLUSTRATIONS

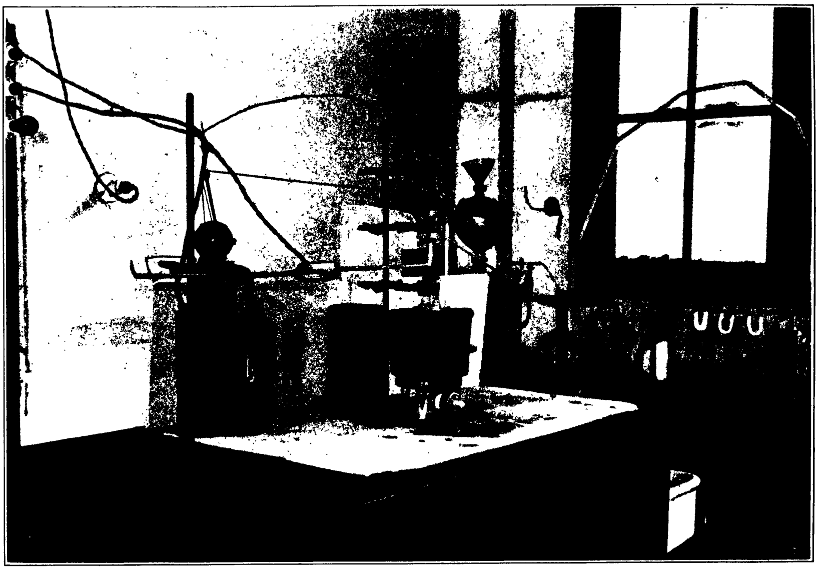

Fig. 1. Side view.

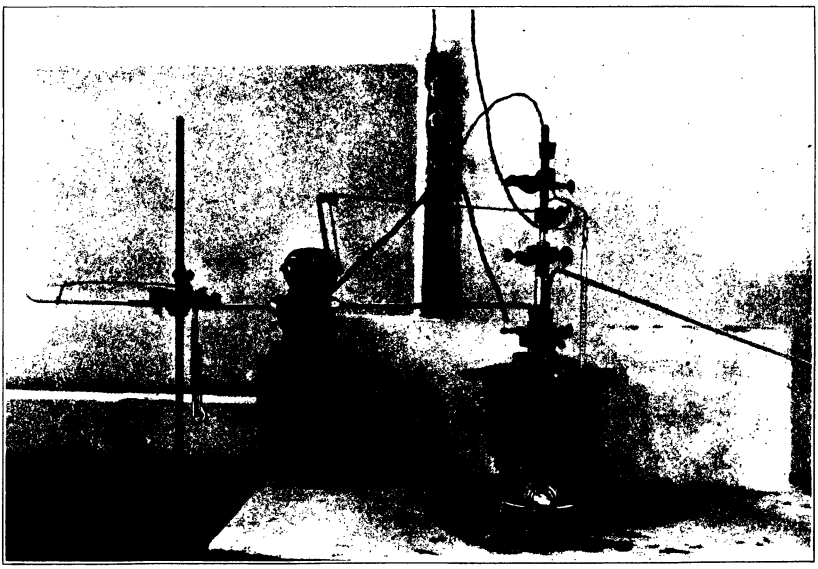

Fig. 2. Front view.

PLATE 1. HYDROGENATION APPARATUS.

SOME NEW MALAYAN CARABIDÆ, ESPECIALLY PHILIPPINE

By K. M. HELLER
Zoölogical Museum, Dresden, Germany

ONE PLATE

The following descriptions of new species are based for the most part upon material collected by Prof. C. Fuller Baker in various localities in the Philippine Archipelago and in Sandakan, northeastern Borneo; upon the material kindly forward to me by Mr. W. Schultze, of Manila, collected by himself, Mr. R. C. McGregor, and Mr. E. H. Taylor; and upon the material in the Dresden Museum, collected by the late Dr. A. Schadenberg.

The species here treated belong to the following tribes:

HELLUONINI

Macrochilus ruficollis sp. nov.
Macrochilus tripustulatus F.

SCARITINI

Thlibops integricollis sp. nov.
Thlibops abbreviatus sp. nov.
Thlibops puncticollis Gestro.
Thlibops crenata Chaudoir.
Thlibops longicollis Putz.
Thlibops dohrni Chaudoir.
Thlibops minor Heller.
Thlibops glabriventris Heller.
Thlibops omega Heller.
Thlibops intermedius Heller.
Thlibops paviei Lesne.
Scarites longiusculus Chaudoir.

PTEROSTICHINI

Anchomenus (Agonum) nigrosericans sp. nov.

TRIGONOTOMINI

Triplogenius (Lesticus) busuangae sp. nov.
Triplogenius (Lesticus) prasinus Tschitsch.
Triplogenius (Lesticus) insignis philippinensis Kuntzen.
Triplogenius (Lesticus) macgregori Kuntzen.
Triplogenius (Lesticus) cupreatus sp. nov.
Trigonotoma luzonica Chaud.
***Trigonotoma** leotaudi* Tschitsch.
Trigonotoma palawanica Tschitsch.

CHLAENIINI

Euschizomerus rufipes var.? *pilosulus* var. nov.
Chlaenius cuspidatus sp. nov.

MASOREINI

Anaulacus sericeipennis philippinensis subsp. nov.

TETRAGONODERINI

Cyclosomus philippinus sp. nov.

DRYPTINI

Desera (Dendrocellus) schultzei sp. nov.
Desera geniculata Klug.
Desera unidentata MacLeay.
Desera parallela Chaud.
Desera smaragdina Chaud.
Desera ternatensis Chaud.

DRYPTINI—Continued

Desera longicollis Dej.
Desera gestroi H. W. Bates.
Desera aeneipes Wied.
Desera discolor Schm. Göb.

LEBIINI

Physodera eburata sp. nov.
Physodera bifenestrata sp. nov.

LEBIINI—Continued

Physodera dejeani Eschsch.
Physodera eschscholtzi Parry.
Physodera parvicollis v. de Poll.
Physodera cyanipennis v. de Poll.
Physodera amplicollis v. de Poll.

HELLUONINI

Macrochilus ruficollis sp. nov. Plate 1, fig. 1.

Macrochilus tripustulatus F. affinis sed minor, piceus, macula frontali thoraceque sanguineis, oris partibus, antennis, pedibus maculisque tribus in elytris, una utrinque longitudinali ovata, ante medium, altera apicali communi, suturali, testaceis; epistomo glabro, punctis setuligeris solum quatuor, fronte per longitudinem capite reliquo multo parcius punctato; prothorace linea mediana paulo latiore (5.4: 6), ad angulos posticos oblique truncato, lateribus ante truncaturam subsinuatis dein obtusangulatis, disco utrinque area longitudinali parcius, impressione in angulis posticis crebre punctato, sulco mediano distincto; elytris macula anteriore inter striam secundam et nonam (submarginalem majus punctatem) sita, posteriore communi striam quartam tangente, margine anteriore bilobato. Long. 9.5, lat. 2.8 mm.

LUZON, Laguna Province, Los Baños (*Baker*).

This species, like *M. tripustulatus* F., exhibits in the anterior half of each elytron a yellowish but larger spot which extends from the second to the marginal stria and an apical spot on the suture, laterally touching the fifth stria and the apical margin. The prothorax is red, proportionately longer than in any other species of the genus, and distinctly more sparsely punctate on each side of the disk than in the other parts; the elytra are nearly twice as long as broad (5.5: 3), the striæ comparatively more distinctly punctate than in *M. tripustulatus* F. *Macrochilus tripustulatus* F. occurs in the Philippines.[1]

SCARITINI

Thlibops integricollis sp. nov.

Thlibops omega m. paullo longior, fronte rugosa, tuberculo, subconico, mediano, instructa; prothorace utrinque impressione, basali, nulla; elytris pro proportione longioribus, maxima latitudine in secundo triente, striis tribus subsuturalibus obsoletis,

[1] Deutsche Ent. Zeitschr. (1916) 269.

solum ad basin observandis ac in parte apicali manifestis, hic spatiis costatis; metasterno lateribus episternisque haud punctatis; sternito abdominali tertio quartoque secundum marginem basalem sat late, primo secundoque lateribus vix punctulatis. Long. 17.5 ad 20.5, lat. 4.5 ad 5 mm.

LUZON, Benguet Province, Baguio: Zambales Province, Iba (*W. Schultze*).

This species can be readily recognized by the rugulose front which bears a conical tubercle in the middle, by the lack of a basal impression on each side of prothorax, and by the obsolete three interior elytral striæ which are distinct only at the base and toward the apex. The specimen from Zambales Province is smaller and shows an obsolete frontal tubercle but agrees in other respects with a smaller specimen of *T. integricollis.*

Thlibops abbreviatus sp. nov.

Thlibops intermedio m. similis, sed fronte tuberculo conico armata; prothorace linea mediana distinctius remote seriato-punctata; elytris spatiis alternatis latioribus ac convexioribus apice abbreviatis et hic haud confluentibus, spatio septimo parte apicali inflato ac ordine suturam attingente; metasterno lateribus episternisque perparce, abdomen fere toto punctato, sternito abdominali praeterea transverse rugoso. Long. 18.5, lat. 3.3 mm.

LUZON, Rizal Province, Montalban (*W. Schultze*).

Differs from all the other Philippine species by the shorter intervals of elytra, which are alternately much broader and more convex and not confluent at the apex. The metasternum and metaepisterna are sparsely rugose, the last three ventral abdominal segments throughout distinctly punctate, and the anal segment is transversely rugose.

The known species of the genus *Thlibops* Putz. (*T. longicollis* Putz., *T. puncticollis* Gestro, and *T. paviei* Lesne I know only from the descriptions) can be distinguished by the following characters:

1 (17). Prothorax with a distinct sulciform basal impression on each side.
2 (7). All striæ of elytra entirely punctate-striate.
3 (4). Sides of prothorax with sparse unequal punctures; length, 11 millimeters. Burma.................................. **T. puncticollis Gestro.**[3]
4 (3). Sides of prothorax without punctures.
5 (6). Second and fourth intervals of elytra without punctures; length, 15 millimeters. Cochin-China .... **T. crenata Chaudoir.**
6 (5). Second and fourth intervals of elytra with four or five remote punctures; length, 9 millimeters. Gabun... **T. longicollis Putz.**

[3] Ann. Mus. Civ. Genova **18** (1822) 302.

7 (2). Striæ of elytra not, or at most the four interior striæ toward apex, punctate-striate.
8 (9). Alternate intervals (3, 5, 7) of elytra with four or five remote punctures; length, 21 millimeters. Java.... **T. dohrni Chaudoir.**
9 (8). All intervals without punctures.
10 (13). Striæ of elytra punctate-striate toward apex.
11 (12). Abdomen distinctly punctate along the middle; length, 12 millimeters. Luzon .... **T. minor Heller.**[3]
12 (11). Abdomen broadly smooth along the middle; length, 13.5 millimeters. Luzon.......... **T. glabriventris Heller.**[4]
13 (10). Striæ of elytra entirely impunctate.
14 (17). Intervals of elytra confluent toward apex.
15 (16). Second interval of elytra (between striæ 1 and 2) in the basal half not more convex than the others and not much broader than the third; length, 21 millimeters. Luzon........ **T. omega Heller.**[5]
16 (15). Second interval of elytra entirely convex and twice as broad as third; length, 20 millimeters. Luzon.. **T. intermedius Heller.**[6]
17 (14). Intervals of elytra abbreviated and not confluent toward apex, exposing a triangular, even apical, space; length, 19 millimeters. Luzon.......... **T. abbreviatus sp. nov.**
18 (1). Prothorax without or with only a feebly indicated basal impression.
19 (20). Striæ of elytra indistinctly, the abdomen not, punctate; length, 12.5 millimeters. Siam.......... **T. paviei Lesne.**[7]
20 (19). Striæ of elytra impunctate, abdomen distinctly punctate on the sides; length, 16.5 to 20 millimeters. Luzon.
T. integricollis sp. nov.

Scarites longiusculus Chaudoir, described from the Philippines without exact locality, occurs at Mansalay, Mindoro, where it was collected by E. H. Taylor (Bureau of Science collection).

PTEROSTICHINI

Anchomenus (Agonum [8]) nigrosericans sp. nov.

A. quadripunctato Dej. (spec. *palaearctica*) similis, sed minus elongatus, capite plus transverso, clipeo minus transverso, polito (in *quadripunctato* subtilissime coriario), prothorace paulo angustiore, minus transverso, angulis posticis plus indicatis; elytris brevioribus, notabiliter albo-sericeo micantibus, lateribus subrotundatis, striis subtilissimis, apicem versus manifeste im-

[3] Deutsche Ent. Zeitschr. (1916) 275.
[4] Deutsche Ent. Zeitschr. (1916) 276.
[5] Abh. Mus. Dresden No. 7 (1899) 3.
[6] Philip. Journ. Sci. **19** (1921) 530.
[7] Bull. Mus. d'Hist. Nat. Paris (1896) 239.
[8] Cf. Semenow, Apercu des genres palaearctic de la Tribu des Anchomenides, Bull. Nat. Moscow 2 (1888) 686.

pressis, stria quinta sextacum in secundo triente conjunctis, spatio secundo marginalique, ut in *quadripunctato, foveolatis,* foveolis duabus postmedianis in spatio secundo alteri minus approximatis, tarsis utrinque haud sulcatis. Long. 5, lat. 2 mm.

LUZON, Benguet Subprovince, Mount Santo Tomas (*W. Schultze*).

Very similar to the European *A. quadripunctatum* Dej. but smaller; the elytra shorter, more rounded on the sides, and strikingly silky white; the fifth and sixth striæ joined in the second third of their length; clypeus smooth (not finely coriaceous as in *quadripunctatum*); and sides of prothorax before the more-distinct posterior angles a little more perceptibly emarginate.

TRIGONOTOMINI

Triplogenius (Lesticus) busuangae sp. nov. ♀.

L. insigni Gestro [9] magnitudine fere aequali, sed elytris plus ovatis ac convexioribus, spatiis multo (fere ut in *assamico* Kuntzen) convexioribus, unicolor violaceus; antennis nigris, articulo tertio primo distincte longiore; fronte utrinque impressione longitudinali, foveolato-dilatata ac crebre punctata, extrinsecus toro, oblique strigoso determinata; prothorace transverso, lateribus postrorsum plus quam antrorsum rotundato-attenuatis, maxima latitudine ante medium, usque ad basin elevato-marginatis, angulis posticis obtusangulatis, area intermarginem lateralem et impressionem basalem (ut impressione) disperse subtiliterque punctata; elytris lateribus rotundatis, stria scutellari brevissima, sulco marginali usque ad striam primam percurrente, ad humeros angulato, crenato-striatis, spatiis convexis, spatio octavo, carinato, reliquis angustiore; episternis disperse fortiterque prothoracis postrorsum parcius punctatis sternito abdominali secundo post coxas seria transversae punctis sex formata, sternitis tres ultimis secundum marginem basalem sulco profundo, crenato-punctato. Long. 25, lat. 9 mm.

BUSUANGA (*Alexander Schadenberg*).

Triplogenius (Lesticus) cupreatus sp. nov.

T. mac-gregori Kuntzen affinis, sed supra unicolor cupreus, prothorace vix perspicue transversim undulato-rugoso, utrinque impressione basali levi, elytris subtiliter punctato-striatis, stria secunda in medio et in secundo triente, stria tertia in quinta parte

[9] Ann. Mus. Civ. Genova 18 (1883) 310.

basali, puncto impressis; sternito abdominali primo secundoque irregulariter transverse punctatis, meso-episternis solum in dimidia parte anteriore punctatis; tarsis articulo primo extrinsecus haud sulcato. Long. 22, lat. 9 mm.

LUZON (*Schadenberg*), Laguna Province, Mount Maquiling (*Baker*). For particulars see the following key:

Synopsis of the Philippine Trigonotomini.[10]

1 (12). Third antennal joint as long as or longer than first, antennæ not geniculate; labrum and epistomum truncate, hardly sinuate.

2 (3). Lateral margin of metasternal episternum longer than its front margin; posterior angles of prothorax usually very obtuse (no Philippine species known)................ **Triplogenius Chaud. s. str.**

3 (2). Lateral margin of metasternal episternum not longer than its front margin; posterior angles of prothorax sharply rectangular. **Triplogenius subg. Lesticus.**

4 (7). Dorsal intervals of elytra convex.

5 (6). Head and prothorax metallic green; elytra greenish black, nearly parallel sided; subscutellar stripe three to four times the length of scutellum; length, 25.5 millimeters. **T. (L.) prasinus Tschitsch.**

6 (5). Head and prothorax like the ovate elytra uniform violaceous; subscutellar stripe hardly more than twice the length of scutellum; basal impressions of prothorax finely punctate; length, 25 millimeters.................................... **T. (L.) busuangae sp. nov.**

7 (4). Dorsal intervals of elytra flat.

8 (9). Upper side violaceous or bluish green; upper side of first posterior tarsal joint outwardly sulcate; subscutellar stripe distinct, confluent with the first stria; basal furrow of elytra consisting only of the short incurvate basal part of the lateral furrow which does not reach fifth stria; length, 23.5 to 24 millimeters. **T. (L.) insignis philippinicus Kuntzen.**

9 (8). Upper side cupreous.

10 (11). Lateral margin of elytra concolorous, prothorax sometimes greenish; abdomen smooth, intermediate episterna nearly entirely punctate, posterior episterna entirely so; length, 17 millimeters. **T. (L.) mac-gregori Kuntzen.**

11 (10). Lateral margin like prothorax and the remaining upper side uniform cupreous; first and second ventral segments with irregular transverse rows of punctures; intermediate episterna punctate, in the anterior half only; subscutellar stripe very indistinct; first joint of posterior tarsi without a lateral furrow; length, 20 to 22 millimeters................ **T. (L.) cupreatus sp. nov.**

12 (1). Third antennal joint much shorter than first, antennæ geniculate; labrum and epistomum strongly sinuate............ **Trigonotoma Dej.**

[10] In the Catalogue of Philippine Coleoptera, Manila (1915) 13, the author confuses the tribe of Trigonomini (not Trigonominæ) with Pterostichini; these are both tribes of the family Harpalidæ.

13 (14). Labial palpi large triangular; basal impression on each side of prothorax smooth, only along its lateral margin with a few punctures, limited internally by a short and feeble furrow; sides of pro- and metasternum distinctly punctate; elytra cupreous; length, 20 millimeters.................. **T. luzonica Chaud.**[11]

14 (13). Labial palpi elongate, moderately enlarged toward apex.

15 (16). Basal impression on each side of prothorax punctate internally and externally to the short furrow; elytra slightly purplish; all episterna feebly punctate; length, 14 millimeters. **T. leotaudi Tschitsch.**

16 (15). Basal impression on each side of prothorax finely punctate; all episterna strongly punctate; elytra black, slightly shining bronzy; prothorax cupreous; length, 17.5 millimeters. **T. palawanica Tschitsch.**

CHLAENIINI

Euschizomerus rufipes[12] var. ? **pilosulus** var. nov.

Specie typica robustior ac distinctius, sat longe, fulvo-pilosus; prothorace praeter punctationem subrugoso, lateribus medio minus dilatatis, elytris aeneis, fortius striato-punctatis, spatiis convexioribus. Long. 9, lat. 3.8 mm.

PANAY, Capiz Province, Culasi (*R. C. McGregor*).

Two specimens sent by Mr. Schultze, collected by Mr. McGregor, differ slightly from the typical specimen from Mount Maquiling in the larger size, and in the longer fulvous pubescence and stronger sculpture of the elytra, the intervals of which are also more convex and the color more bronzy. More-extensive material will perhaps make it necessary to separate this form as a subspecies or a species.

Chlaenius cuspidatus sp. nov.

Niger, opacus, capite viridi-aeneus, oris partibus, antennarum articulo primo pedibusque, tarsis infuscatis exceptis, testaceis, elytris signatura, communi, subapicali, cuspidata, lutea; capite creberrime subruguloso-punctato, sine impressionibus; prothorace, ut elytris, subtiliter crebreque granuloso, transverso, lateribus postrorsum plus quam antrorsum rotundato-attenuatis, margine antico subsinuato, angulis anticis obtusis, posticis obtusangulatis, sulco mediano distincto, intra angulis posticis

[11] Chaudoir, Ann. Soc. Ent. Belg. 11 (1888) 16, indicates 30 millimeters as the length of this species, probably in consequence of a misprint, otherwise he would have mentioned the extraordinary size. A specimen collected by Prof. C. Fuller Baker on Mount Maquiling (*13977*) agrees sufficiently with the description of *T. luzonica* Chaud. except that its length is 20 millimeters.

[12] The species is described in Philip. Journ. Sci. 19 (1921) 526.

impressione longitudinali; elytris sulco basi-marginali ad humeros haud angulato, subtilissime pubescentibus, signatura lutea, suturali, e lineolis in sutura, spatio primo secundoque dispositis formata. Long. 7, lat. 3 mm.

LUZON, Laguna Province, Los Baños (*14281*). MINDANAO, Davao Province, Davao (*Baker*).

This species resembles in sculptural characters the European *C. holosericeus* F. but is of much smaller size; the head metallic green, first joint of antennæ, mouth parts, and legs, except the infuscate tarsi, fulvous; an arrowhead-shaped subapical figure on the suture luteous. The prosternum is not marginate; third joint of antennæ longer than the following ones; labrum emarginate, testaceous.

MASOREINI

Anaulacus sericeipennis[13] **philippinensis** subsp. nov. Plate 1, fig. 2.

Differt a specie typica; elytris macula lutea, humerali, margine interno sutura parallelo, macula subapicali extus in margine laterali usque ad suturae apicem producta, margine laterali reliquo usque ad basin nigro. Long. 6, lat. 3.2 mm.

MINDANAO, Lanao Province, Iligan (*Baker*).

Like *fasciatus* Schm. Göb., I take *philippinensis* only for a subspecies of *sericeipennis* MacLeay, the chief difference lying in the pattern of the elytra as shown in the illustration.

TETRAGONODERINI

Cyclosomus philippinus sp. nov. ♀. Plate 1, fig. 3.

Cyclosomo flexuoso F. affinis, sed minor, lateribus plus rotundatis, elytris fascia submediana lata, nigra, foris abrupte attenuata ornatus, rufo-piceus, labro abdomine apicem versus, prothorace lateribus vitta marginali, lata, rufo-testaceis, palpis, antennis, pedibus elytrisque testaceis, his sutura tota, spatiis 1.-4. basi, spatiis 1.-3. praeterea in secundo treinte, 4.-6. in parte mediano nigricantibus, fasciam communem usque ad striam septimam, intra striam tertiam fere usque ad elytrorum apicem extensam, formantibus; striis fortius impressis, exterioribus (ab stria sexta) distincte seriato-punctatis. Long. 7.5, lat. 4.6 mm.

LUZON, Laguna Province, Los Baños (*Baker*).

Differs from *C. flexuosus* F.[14] in its smaller size, in the three more-convex interior intervals, the finely but distinctly punctate

[13] Cf. Chaudoir, Bull. Soc. Nat. Moscow II 51 (1876) 23.

[14] Cf. Dupuis, Revue Zoologique Africaine. Bruxelles 1 (1912) 384; and Chaudoir, Bull. Soc. Moscow II 51 (1876) 29.

fifth exterior stria, and the differently shaped blackish design of the elytra which is best shown by the figure (Plate 1, fig. 3). In *C. flexuosus* F. the design consists only of a narrow interrupted band representing the remaining posterior border of the reduced band of *C. philippinus*.

DRYPTINI

Desera[15] **(Dendrocellus) schultzei** sp. nov.

Desera gestroi Bates[16] affinis, capite prothoraceque nigrocyaneis, oris partibus antennisque, his articulo primo dimidiato, nigro, excepto, ferrugineis; elytris nigris, ut capite prothoraceque subtiliter ochraceo-pubescentibus, femoribus tibiisque totis aterrimis, tarsis subrufescentibus; capite genis oculorum diametro dimidiato longitudine vix aequalibus; prothorace densissime ac transverse confluenter punctato, sulco mediano distincto; elytris vix olivascentibus, postrorsum ampliatis, apice angulo externo dentato, striis in dimidia parte basali fortiter, reliquis obsoletius punctatis, interstitiis basin versus convexioribus, fortiter crebreque punctatis. Long. 10.5, lat. elytror. 3.5 mm.

LUZON, Rizal Province, Montalban Gorge (*W. Schultze*).

Key to Indo-Australian species of Desera.

1 (12). Femora predominantly yellow or reddish yellow, sometimes black on apex.
2 (11). Tibiæ predominantly yellow or reddish yellow.
3 (6). Apical margin of elytra with a sharp edge on the outside. India Or., Java, Japan, etc. .... **D. geniculata** Klug.
4 (5). Elytra slightly dilated toward apex. Java. **D. unidentata** MacLeay.
5 (4). Elytra parallel. Sumatra .... **D. parallela** Chaud.
6 (3). Apical margin of elytra obtuse angulate on outer edge.
7 (10). Prothorax with more-rounded sides than in *unidentata*.
8 (9). Color light green .... **D. smaragdina** Chaud.
9 (8). Color olivaceous .... **D. ternatensis** Chaud.
10 (7). Prothorax cylindrical with parallel sides in anterior third. Nepal, Calcutta, Burma .... **D. nepalensis** Hope.
11 (2). Tibiæ black, femora yellow, black on apex. India Or. **D. longicollis** Dej.
12 (1). Femora blackish, greenish or bluish black, at most the base yellowish.
13 (18). Tibiæ black.
14 (17). Elytra unicolorous.

[15] Leach, The Coleopterist's Manual, London, Part 2 (1838) 97 and 105, has priority over Schmidt Göbel's name *Dendrocellus*.

[16] Ann. Mus. Civ. Genova 32 (1892) 385.

15 (16). Femora piceous, red on the base; intervals of elytra a little punctate. Burma .... **D. gestroi** H. W. Bates.[17]

16 (15). Femora entirely deep black; intervals of elytra strongly and densely punctate. Luzon .... **D. schultzei** sp nov.

17 (14). Elytra deep cupreous on disk, broadly brassy green on base and apex. India .... **D. aeneipes** Wied.

18 (13). Tibiæ and tarsi yellowish, femora bluish black. Martaban, Burma. **D. discolor** Schm. Göb.

LEBIINI

Physodera eburata sp. nov. Plate 1, fig. 4.

Subviolaceo-nigra, elytris singulis inter striam tertiam et octavam callositate, discali, reniformi, eburnea; antennis articulis quatuor, basalibus, cyaneis, glabriusculis, reliquis pubescentibus, articulis 6.– 10. depressis, fere quadratis; fronte in dimidia parte anteriore utrinque longitudinaliter rugosa; prothorace in trienti exteriore deplanato, disco sulco mediano utrinque minute parceque, secundum marginem basalem fortiter inaequaliterque punctato, angulis posticis obtusangulatis; elytris latis, latitudine vix una tertiaque parte longioribus, in dimidia parte basali nitidis, in parte post callositatem opacis, striato-punctatis, striis post callositatem evanescentibus; corpore subter nigro-cyaneo, vix punctato. Long. 10.5, lat. 5 mm.

LUZON, Laguna Province, Los Baños (*Baker*).

For particulars see the key to the species.

Physodera bifenestrata sp. nov. Plate 1, figs. 5, 6.

Aterrima, elytris subviolascentibus, singulis plaga longitudinali, elliptica, permagna, lutea, intus stria prima approximata, extus stria extrema tangente, ornatis; antennis articulis, ab quinto ad undecimo, transversis; fronte in dimidia parte anteriore utrinque vix rugoso; prothorace area discali transversa, pulvinata, haud, margine postico disperse punctato, angulis posticis rectis; elytris totis nitidis, in parte ante maculam luteam striato-punctatis, solum stria subsuturali usque ad apicem continuata, in tertia parte apicali evanescenti; corpore subter aterrimo, nitido, vix punctato. Long. 9.5, lat. 4.5 mm.

BORNEO, Sandakan (*Baker*).

For particulars see the following key to the species:

Key to the known species of Physodera.

1 (6). Upper side with ivorylike callosities; antennæ from the fifth joint strongly flattened and moderately dilated.

[17] Ann. Mus. Civ. Genova 32 (1892) 385.

2 (3). Prothorax on each side with an ivorylike callosity. Philippine Islands, Tenasserim, eastern Sumatra, Deli, Medan, Balabac Island.. **P. dejeani** Eschsch.

3 (2). Prothorax without, but elytra with an ivorylike patch on disk.

4 (5). The flattened, slightly concave lateral part of prothorax one-fourth as broad as entire thorax, its disk convexly elongately arched, on each side with a few fine punctures; elytra dull in apical part, each with a subtransverse, reniform, ivorylike callosity on disk. Los Baños, Laguna Province, Luzon. **P. eburata** sp. nov.

5 (4). The flattened lateral part of prothorax only one-sixth of its breadth, the arched part of disk transverse, subelliptical, smooth; elytra with a longitudinal subcallose yellowish spot, its apical part shining. Sandakan, Borneo............. **P. bifenestrata** sp. nov.

6 (1). Upper side without ivorylike callosities.

7 (12). Prothorax unicolorous, greenish or bluish.

8 (11). Elytra bronzy, more or less glistening purplish.

9 (10). Prothorax more than one and one-half times as broad as long at middle (3.4 : 2). Philippine Islands, Ceylon, Sumatra, Deli, Borneo, Java, China (*davidis* Fairm. i. l.).. **P. eschscholtzi** Parry.

10 (9). Prothorax much smaller than in the preceding species, less than one and one-half times as broad as long at middle. Hongkong (perhaps merely a subspecies of the preceding). **P. parvicollis** v. de Poll.[18]

11 (8). Elytra steel blue. Celebes..................... **P. cyanipennis** v. de Poll.[18]

12 (7). Prothorax fulvous with an irregular black dorsal vitta and a large round black lateral spot (this may be variable); elytra purplish black, apex edged with testaceous. **P. amplicollis** v. de Poll.[18]

Allocota cyanipennis sp. nov.

A. viridipennis Motsch. simillima sed paulo brevior ac latior, capite prothoraceque plus cinnabarinis; elytris pulcherrime chalybeis, striis multo subtilioribus, stria subsuturali apice excepta, haud impressis, sternitis abdominalibus, 3., 4., et 5., distinctius punctatis. Long. 6.5, lat. 2.4 mm.

MINDANAO, Bukidnon Province, Tangcolan (*Baker 14261*).

Besides the greater redness of the head and prothorax and the steel blue elytra, this species differs from *viridipennis* Motsch.[19] also by the shorter and much finer seriate-punctate elytra, which, except the sutural stria toward the apex, are by no means sulcate; whereas in *viridipennis* all the striæ, especially the first, second, fifth, and sixth, are impressed toward the apex so that the interval between the seventh and eighth striæ forms a striking oblong callosity in the apical third.

[18] Notes Leyden Museum 11 (1889) 251–256.

[19] This species I have before me in specimens collected by Prof. C. Fuller Baker at Puerto Princesa, Palawan, and at Sandakan, Borneo.

ILLUSTRATION

[From drawings by Heller.]

PLATE 1

FIG. 1. *Macrochilus ruficollis* sp. nov., thorax.
2. *Anaulacus sericeipennis philippinensis* subsp. nov., left elytron.
3. *Cyclosomus philippinus* sp. nov., left elytron.
4. *Physodera eburata* sp. nov.
5. *Physodera bifenestrata* sp. nov., elytra.
6. *Physodera bifenestrata* sp. nov., antenna.

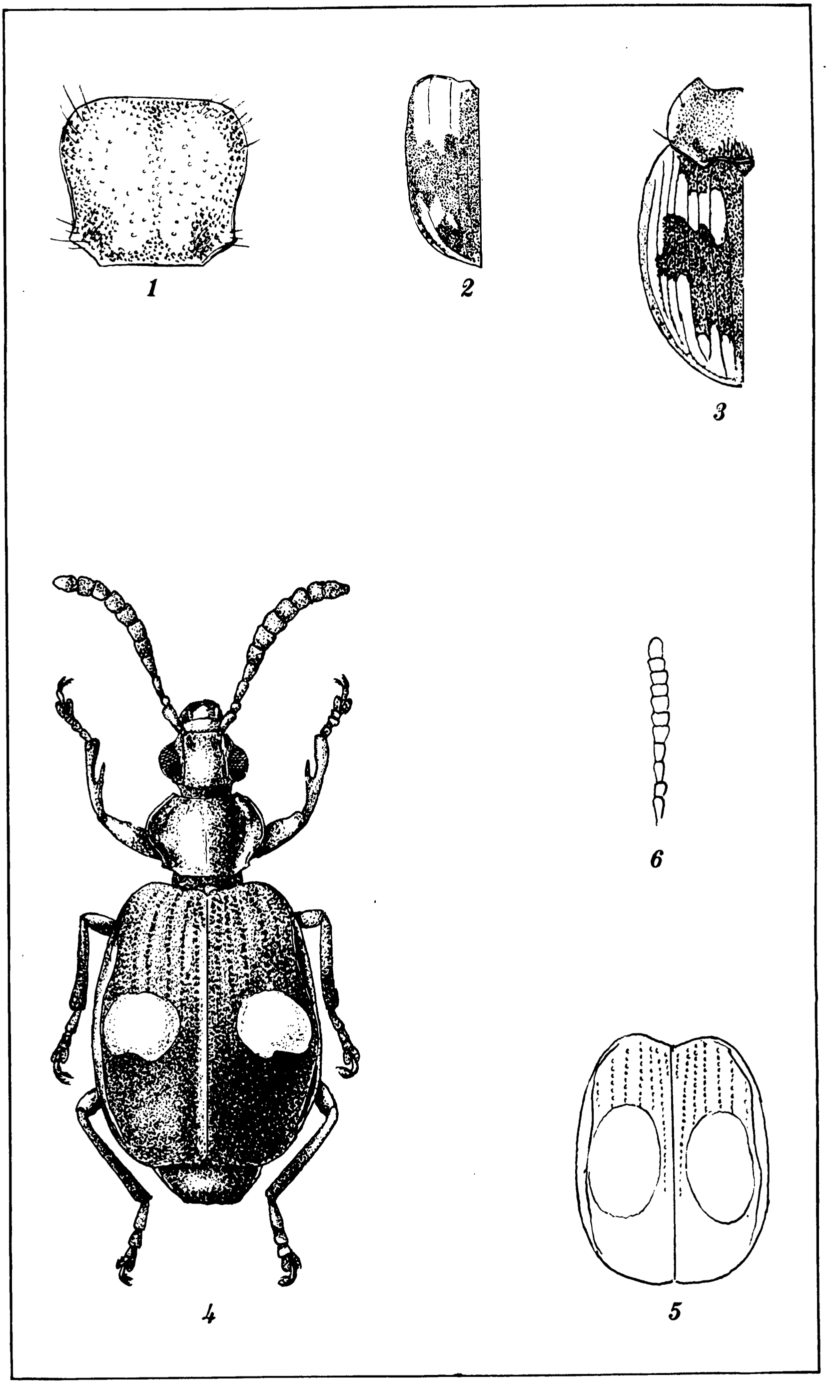

PLATE 1.

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THE PHILIPPINE JOURNAL OF SCIENCE

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SOME PHILIPPINE SPECIES OF THE GENUS MUSCA LINNÆUS

By W. S. PATTON

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In August, 1922, during my visit to Prof. M. Bezzi at Turin, he very generously gave me a large collection of species of *Musca* from the Philippine Islands to describe. The specimens, 151 in number, were collected by Prof. C. F. Baker, in the vicinity of Los Baños, Laguna Province, in Baguio, Benguet Subprovince, Luzon, and in two localities in Mindanao; by Mr. R. C. McGregor in Panay and Batbatan Islands; and by Mr. M. B. Mitzmain in Alabang, Rizal Province, Luzon. The specimens collected by the latter are of peculiar interest, as some of them are the hæmatophagous species referred to in his well-known investigations into the method of transmission of the trypanosome of surra in the Philippine Islands. I believe they were caught on animals in association with biting flies such as *Stomoxys calcitrans*. Bezzi[1] has already recorded two species of *Musca*, *M. crassirostris* Stein and *M. inferior* Stein, from these Islands. In addition, *M. conducens* Walker, *M. niveisquama* Thomson, *M. bivittata* Thomson, and *M. favillacea* Walker have also been recorded from the Philippines. As these Islands form a part of the Oriental Region, it is only natural to expect that the species of this genus, as Professor Bezzi has pointed out in the case of other dipterous genera, would be to a large extent identical with those from other parts of the

[1] Philip. Journ. Sci. § D 8 (1913) 305.

Region, and the present collection clearly shows this to be the case.

As I have now studied nearly all the existing types of the genus *Musca*, I am in a position to give the species their correct and final names, as well as all the synonyms. In studying any large collection of species of this genus it is not only convenient but also most satisfactory to deal with them in three groups, into which they naturally fall as follows:

GROUP I

The nonbiting, occasionally hæmatophagous, true house- and bazaar-frequenting species, which, though often found on animals, are mainly associated with man, his dwellings, and his food. They breed in garbage and excrement of all kinds and regularly feed on these. It is hardly necessary to point out that the species of this group are some of man's most-dangerous insect pests; but, unfortunately, we are not able to gauge with any degree of accuracy the amount of harm they do. Although no one has yet succeeded in isolating known species of pathogenic bacteria from wild specimens (that is, flies caught in houses and bazaars), practical experience has taught us to regard them as certain carriers of pathogenic bacteria, helminth eggs, and parasitic protozoa from excrement to the human body and to food of all kinds. More than one species is the invertebrate host of species of *Habronema* parasitic in horses and cattle.

GROUP II

The nonbiting, hæmatophagous species comprising this group are only found on animals and in their vicinity, and breed almost exclusively in cow dung. There is very little doubt that the species of this group are mechanical carriers of blood parasites and bacteria from one animal to another. Anyone who has observed their habits in the field will be in a position to appreciate their potentialities in this direction. Representatives of this group are to be found in most parts of the world feeding on cuts, abrasions, wounds, sores, and the discharge from the eyes of animals, as well as on the blood and serum which exude from the bites of true biting flies. Owing to the nature of their food, these species are essentially intermittent feeders and may be seen flitting from one animal to another in search of food. But here again Mitzmain has shown that some of them are certainly under suspicion as carriers of pathogenic trypanosomes, but there is at present no experimental proof that they

are the vectors. Several species are known to be suitable invertebrate hosts of species of *Habronema,* and the evidence so far seems to point to their being the transmitters of these helminths to equines and bovines. They should always be taken into consideration when investigating an outbreak of any parasitic disease among animals, and are therefore of importance in veterinary medicine.

GROUP III

This group consists of the true biting-blood-sucking species which are only found on animals and in their vicinity, and which breed exclusively in cow dung. Although there is no experimental or other evidence to show that any of the species of this group are associated in the transmission of disease-causing organisms to animals, as blood-sucking flies they must be looked on with suspicion.

I will now deal with the species according to the groups to which they belong and in the above order.

SPECIES OF GROUP I

Musca vicina Macquart.

Musca flavinervis Thomson.
Musca atrifrons Bigot.
Musca flavifacies Bigot.
Musca flavipennis Bigot.
? *Musca biseta* Hough.
? *Musca divaricata* Awati.
Musca determinata Patton (nec Walker).

The collection contains 5 males and 3 females from Manila (*McGregor*) and 2 males and 8 females from Alabang, Rizal Province, Luzon (*Mitzmain*). The specimens, with the exception of one female, agree with Macquart's types of *Musca vicina,* and are the species referred to by me in a recent paper as *Musca domestica* (atypical), in which the male has a very much narrower front than the typical *domestica* L. In that paper I expressed the opinion that the following were probably also this species:

Musca sanctae-helenae Macquart, Saint Helena.
Musca lateralis Macquart, Mauritius.
Musca basilaris Macquart, Brazil and Mexico.
Musca frontalis Macquart, Chili.
Musca analis Macquart, Chili.
Musca consanguinea Rondani, Mexico.
Musca senegalensis Macquart, Senegal.
Musca flavinervis Thomson, Ross's Island.

Musca antiquissima Walker, Australia.
Musca calleva Walker, South Africa.
Musca vicaria Walker, New Zealand.
Musca pampasiana Bigot, Buenos Ayres.

I have since examined the type of *Musca flavinervis* Thomson at Copenhagen, and find it is this species, thus confirming my previous determination. But a reëxamination of Bigot's and Walker's types has led to the final conclusion that *M. antiquissima, calleva, vicaria,* and *pampasiana* are identical with *M. domestica* L. I was unable to find the types of either Macquart's *M. sanctae-helenae, lateralis, basilaris, frontalis,* or *analis* in Paris, and therefore I propose finally deleting these names from the literature, for it is quite impossible to be certain what they are, from Macquart's commonplace descriptions. I have not seen the type of *M. consanguinea,* but Professor Bezzi tells me it is *M. domestica* L. I have also not as yet seen the type of *Musca biseta* Hough, which I believe is in Philadelphia. I have been unable to find out where the type of *M. divaricata* Awati is, and, unless it is forthcoming, I propose dropping this name later. As *M. vicina* is the oldest name of this species, the type of which I have seen, I propose adopting this name in future for the species of *Musca* which is like *M. domestica* L., but in which the male has a much narrower front.

Musca vicina is widely distributed in the Tropics, and is a common house fly. The male is easily distinguished from that of *M. domestica* L., by its narrower front, which is about one-seventh to one-eighth the width of the eye, and about half that of *M. domestica.* The female is very like that of *domestica* and difficult to distinguish from it, but the parafacials are a little wider and the frontal stripe is distinctly narrower; the apparent first and second abdominal segments, especially the former, are lighter orange than those of *domestica,* in which they are usually dark brown or black. One female in the collection is indistinguishable from the European *domestica,* and it is very probable that this species occurs in the Islands. A more extensive collection of house and bazaar flies would be of great interest in this direction.

Musca nebulo Fabricius.

Musca determinata Walker.
? *Musca multispina* Awati.

There are 3 males of this widely distributed Oriental species in the collection, 2 from Alabang, Rizal Province (*Mitzmain*),

and 1 from Manila (*McGregor*). I have always been doubtful as to the accuracy of the determination of this species with the *M. nebulo* of Fabricius, and hoped to have settled my doubt one way or the other by an examination of the type at Kiel. The type of *M. nebulo* has, however, shared the fate of the rest of the collection of Fabricius, and is now only represented by a pin and a label. It is quite impossible to be certain as to what Oriental species Fabricius had before him when he wrote his very inadequate description and, when on my way to Copenhagen from Kiel, I had decided finally to delete this name from the literature and to rename the species *M. determinata* Walker. When I came to examine the Fabrician collection at Copenhagen, I found two specimens, one a male and the other a female, bearing the label *nebulo,* in the handwriting of Fabricius; the former is the common Oriental house fly, but the latter is *M. humilis* Wiedemann. I therefore propose retaining the name *nebulo* finally for the common Oriental house fly. I have no knowledge of the whereabouts of the type of *M. multispina* Awati.

Musca nebulo may be confused with *M. vicina.* The frons of the male is about as wide as that of *M. vicina;* but, whereas the orbital margins of the latter are parallel almost to the vertex, those of the former curve in just above the middle so that the frons is distinctly waisted just below the vertex. The abdomen of *M. nebulo* is lighter, especially the apparent third segment; in *M. vicina* the abdomen is dark orange, and the third segment has a dark brown admedian stripe; the apparent fourth segment is also much darker. The female of *nebulo* is also much lighter in color than the female of *vicina,* and has well-marked silvery stripes and spots on its abdomen.

Musca sorbens Wiedemann.

Musca humilis Wiedemann.
Musca spectanda Wiedemann.
Musca latifrons Wiedemann.
Musca mediana Wiedemann.
Musca sordissima Walker.
Musca primitiva Walker.
Musca angustifrons Thomson.
Musca bivittata Thomson.
Musca scapularis Rondani.
Musca euteniata Bigot.
Musca conducens Patton (nec Walker).
Musca praecox Patton (nec Walker).

The collection contains 5 males of this species, 4 from Baguio, Mount Maquiling, and Los Baños (*Baker*) and 1 from Batbatan

(*McGregor*); 3 females from Los Baños (*Baker*) and 1 from Culasi, Panay (*McGregor*). Since writing my notes on this species in the paper referred to above, I have examined Wiedemann's types of *Musca sorbens, humilis, latifrons, mediana,* and *spectanda* and find they are all identical; *sorbens,* being the oldest name, must, I regret to say, replace the well-known name *humilis.* I have also examined the types of *Musca angustifrons* and *bivittata,* and am now able to confirm Stein's determination; but the type of *niviesquama* Thomson is not *sorbens* but *vetustissima* Walker. Professor Bezzi tells me he has examined the type of *scapularis* Rondani and that it is identical with *sorbens. Musca sordissima,* the type of which I have examined, is also this species. I wish here to correct a mistake made in the determination of Walker's types of *conducens* and *praecox.* A reexamination clearly shows that they are not *sorbens* but the Oriental species known as *lineata* Brunetti, which name now becomes a synonym of *conducens.*

Musca sorbens is a very variable species, and these specimens from the Philippines are darker than most of the Oriental and Ethiopian specimens, and the apparent first abdominal segment of the male is dark brown. However, I have in my collection from India a long series of bred and caught specimens which exhibit variations from the light first abdominal segment to the dark brown type as seen in the Philippine specimens; many of the African specimens also exhibit this variation in color. In all other respects the present specimens are typical.

The width of the frons of the male of *Musca sorbens* is also very variable, as has already been pointed out by Stein. The females do not vary much, either in color or in structural characters; the Philippine specimens are typical.

Musca vetustissima Walker.

Musca pumila Patton (nec Macquart).
Musca minor Patton (nec Macquart).
Musca humilis Stein and authors (nec Wiedemann).
Musca corvina Froggatt (nec Fabricius).
Musca niviesquama Thomson (nec Stein).

The collection contains 1 male from Los Baños (*Baker*), and 5 females from Alabang, Rizal Province, and Culasi, Panay (*McGregor*), also from Baguio and Los Baños (*Baker*). In my notes on the Oriental species of the genus, in the paper mentioned above, I have recorded this species under the name *Musca pumila* Macquart, but as I have been unable to find any

types of this species in Paris I propose deleting the name from the literature and, instead, naming this species *vetustissima,* the type of which I have examined. It is quite impossible to be certain of the identity of Macquart's *pumila,* from his usual commonplace description. The types of *Musca minor* Macquart are nothing more than *domestica* L.; *Musca vetustissima* has been confused repeatedly with *Musca sorbens* (*humilis*) ; and Froggatt has noted it under the name *corvina,* which is, however, a very different species.

The Philippine specimens of *Musca vetustissima* are darker than the Indian specimens, but here again a long series of bred specimens from India clearly demonstrates the variability of the species.

Musca vetustissima is a common bush and camp fly, and is a well-known human pest in Australia; it is believed on good evidence to be the carrier of the bacteria of infective conjunctivitis and allied conditions. Like *sorbens* it is commonly found on animals far from human dwellings, and its breeding habits are very similar. With *sorbens* it links the species of Group I with those of Group II. It can always be distinguished from *sorbens* by its bluer color and the narrower front of the male.

SPECIES OF GROUP II

Musca ventrosa Wiedemann.

Musca xanthomela Walker.
Musca nigrithorax Stein.
Musca pungoana Karsch.
? *Musca kasauliensis* Awati.

There are 2 females of this very characteristic species in the collection, 1 from Los Baños and the other from Mount Maquiling (*Baker*). I have examined the type of *Musca ventrosa,* as well as that of *M. pungoana,* and note that the latter is identical with the former. I have not yet seen the type of *M. nigrithorax* Stein, but its author states it is identical with *M. ventrosa.*

Musca ventrosa can always be recognized by its bluish thorax with four dark stripes and the bright orange abdomen without any markings. The specimens in the collection are typical.

Musca craggi Patton.

The collection contains 5 males from Culasi, Panay (*McGregor*), Mount Maquiling, Dapitan, and Puerto Princesa (*Baker*) ; and 6 females from Alabang (*Mitzmain*), Culasi, Panay (*Mc-*

Gregor), Los Baños, Mount Maquiling, Tacloban, and Puerto Princesa (*Baker*). This species was described recently from southern India. The male may be mistaken for a small specimen of *Musca sorbens*, but the thoracic stripes are well separated, and the median pair are always very narrow in front of the suture; this character is extremely constant in both sexes. The abdomen of the female is reddish brown with dark stripes and bands.

Musca bakeri sp. nov.

Male.—Fourteen specimens from Los Baños, Mount Maquiling, Mount Banahao, and Zamboanga (*Baker*); from Culasi, Panay, and Batbatan (*McGregor*); and from Alabang (*Mitzmain*). Average length of specimens, 8.5 millimeters. Frons very narrow, about one-fifteenth width of eye; eyes bare and almost meeting; frontal stripe a narrow black line; parafrontalia and cheeks silvery gray; antennæ and palpi black; proboscis normal.

Thorax bluish gray with four broad, black, well-separated stripes. The middle pair extend to the anterior margin of the thorax, are not interrupted at the suture, and are distinctly wider behind it; the outer pair are broad, somewhat triangular in front of the suture, and extend without interruption to the margins of the scutellum. They are wider than the presutural portion of the inner pair, and converge toward them. The scutellum is yellowish, and the median dark band is often constricted in the middle, forming two spots.

Abdomen with apparent first segment black, but in two specimens only the anterior part is black with a broad median stripe, and in a third the majority of the segment is black including the median stripe, the remaining narrow basal strip is dark brown. In spite of these marked differences I have no hesitation in saying that these three specimens are identical with the more-typical forms. Apparent second segment either light or dark brown (the latter in the majority of the specimens), with a broad black median stripe and a narrow, black, anterior band extending the length of the middle third of the segment, and a large light silvery yellow admedian spot or patch, and silvery yellow patches at the extreme edges of the tergite; apparent third segment very similar, except that the marginal patch is larger and between it and the admedian spot there is a broad, triangular, clove brown stripe, and in many

of the specimens a narrow, black, basal band; apparent fourth segment exactly similar to the third. Sternites black, forming a characteristic ventral black band which is lighter in the paler specimens noted above. Wings clear, radio-medial root vein normally with four long bristles, sometimes three or even two; and a row of bristles on the lower surface of vein R_{4+5} extending well beyond the radio-medial cross vein. Squamæ whitish yellow and bare.

Female—Twenty-six specimens from Baguio, Mount Maquiling, Los Baños, Mount Banahao, Tacloban, Dapitan, and Zamboanga (*Baker*), and from Culasi, Panay (*McGregor*). Average length of specimens, 8.5 millimeters. Frons more than half the width of the eye; frontal stripe narrow and about half the width of the frons with straight edges; parafrontals wide, silvery gray, with two rows of small bristles; vertex dark; cheeks silvery; antennæ, palpi, and proboscis as in male.

Thorax more silvery and stripes a little narrower than in the male. Abdomen grayish, and when rubbed brownish with black stripes and bands. Apparent first segment black with bluish gray admedian patches often extending almost the whole width of the segment and forming a band; apparent second segment gray with a broad median black stripe and two narrow lateral ones which broaden out at the lower border of the segment forming narrow black bands externally; in addition, a narrow black band along the anterior border of the segment; apparent third segment exactly similar but without an anterior band; apparent fourth segment yellowish gray with a broad median stripe, and often narrow lateral ones. Characters of wings, squamæ, legs, etc., similar to those of the male.

I have much pleasure in naming this striking species in honor of Prof. C. F. Baker, who has contributed much to our knowledge of the Diptera of these Islands.

Musca bakeri is closely allied to *M. bezzii* Patton and Cragg and *M. hervei* Villeneuve, recently described from Tonking and China. The male differs from that of *bezzii* by its lighter-colored thorax and narrower stripes; by the markings of the apparent first abdominal segment, which in *bezzii* always has a patch of light brown along the lower border, and which does not extend to the middle line; by the fewer number of hairs on the radial root vein (normally there are seven in *bezzii*); and by the black sternites. The female differs from that of *bezzii* by its narrower parafrontals, especially just above the level of the bases of the antennæ, and by the fewer number of hairs on the radio-medial

root vein; they are, however, difficult to distinguish. The male of *bakeri* can be distinguished from the male of *hervei* by the portions of the tergites adjoining the sternites being brown, whereas in *hervei* they are black; and in *hervei* there are no bristles along the lower border of vein R_{4+5}. Although I have seen the female of *hervei* in Doctor Villeneuve's collection, I have not studied it sufficiently closely to note how it differs from *bakeri*.

Several of the specimens of *Musca bakeri* in the collection show evidences of having ingested blood, suggesting clearly the habits of this species. I have no doubt it is the species referred to by Mitzmain in his work on surra. It would be interesting to know whether or not this species is larviparous.

The types and most of the cotypes have been returned to Professor Bezzi; I have several cotypes in my collection for further study.

SPECIES OF GROUP III

Musca conducens (Walker).

Musca praecox Walker.
Pristirhynchomyia (*Philaematomyia*) *lineata* Brunetti.
Musca humilis Patton (nec Wiedemann).

The collection contains 8 males from Los Baños and Mount Maquiling (*Baker*) and from Batbatan (*McGregor*) and 17 females from Los Baños and Mount Maquiling (*Baker*) and from Culasi, Panay (*McGregor*). The males are typical specimens of this small, very variable species, but the females are darker and have broader abdominal bands. In my paper on the Oriental species of the genus, referred to above, I stated that the types of *Musca conducens* and *M. praecox* were small examples of *M. sorbens*, but on reëxamining them and comparing them with some fresh material from India I now see that they are the species described by Brunetti under the name *lineata*. It is important to note that the thoracic stripes of the males of this species are often so close together as to appear to be united. These specimens can easily be mistaken for small examples of *M. sorbens* Wiedemann.

Musca conducens belongs to both the second and the third groups and links the two together. It is hæmatophagous and, though unable to draw blood, has well-developed prestomal teeth which are reduced in number and are certainly capable of scratching off a small scab or clot of blood.

Musca (Awatia; Philaematomyia) planiceps Wiedemann.

Musca cingalaisina Bigot.
Musca pollinosa Stein.
Philaematomyia indica Awati.

The collection contains 2 males from Dapitan and Zamboanga, Mindanao (*Baker*), and one female from Dapitan (*Baker*). I have examined the types of *Musca planiceps* Wiedemann in Copenhagen and note that they are this common Oriental species. Though I have not seen the types of *pollinosa* Stein and *indica* Awati, I have no doubt they are identical with *planiceps*.

Musca planiceps is of peculiar interest for, though undoubtedly a bloodsucker, neither Mr. Senior-White nor myself have ever seen it sucking blood, though we have both observed its habits in the field. It is larviparous in habit and deposits one larva at a time in the early third stage.

Musca (Philaematomyia; Ptelolepis) inferior Stein.

Philaematomyia gurneyi Patton and Cragg.

The collection contains 5 males from Los Baños, and Zamboanga and Davao, Mindanao (*Baker*) and 7 females from Los Baños, Mount Maquiling, and Zamboanga (*Baker*). This species is a true bloodsucker, as it is able to scratch the skin and draw blood with its prestomal teeth. It is never seen in large numbers, and when first taken by me at Kodaikanal (6,000 feet), Pulney Hills, southern India, I caught only twelve specimens. Recently Mr. Senior-White sent me a large number collected at the Government Dairy Farm, Colombo, where it is apparently a common species. Mr. Senior-White has found its larva in cow dung, but never in large numbers, clearly suggesting it is larviparous in habit. I have no information as to whether or not the Philippine specimens were caught on cattle in the act of sucking blood.

Musca inferior can be easily recognized by the presence of hairs on the dorsal and middle aspect of the squamæ.

Musca crassirostris Stein.

Musca modesta de Meijere.
Philaematomyia insignis Austen.

The collection contains 1 male and 3 females from Baguio, Benguet Subprovince, 3 females from Los Baños, Luzon, 1 female from Tacloban, Leyte, and 1 male from Cagayan, Mindanao (*Baker*); 1 female from Davao (*Baker*); and 1 male from Culasi,

Panay (*McGregor*). The specimens agree in every detail with those from other parts of the Oriental and Ethiopian Regions. I have no doubt that this is Stein's species *crassirostris,* but I hope soon to have the opportunity of examining the type and settling this point. With Professor Bezzi, I came to the conclusion that *Musca modesta* de Meijere from Java is also this species, and Professor de Meijere tells me that this is the case, and that Stein had also come to the same conclusion. I have examined the type of *insignis* and there is no doubt that it is identical with *crassirostris.*

Musca crassirostris can be easily recognized by its dark gray or olive-green to blackish coloration; by its narrow thoracic stripes; and by the characteristic abdominal markings. The apparent first abdominal segment is dark anteriorly, the lower border often edged with a narrow black band; the apparent second segment is edged anteriorly with a narrow black band and a complete or incomplete median stripe; the apparent third segment usually has a small anterior median spot or stripe. An examination of the proboscis will always confirm the determination; the large shining bulb, or mentum, is very characteristic, and when the teeth are everted they can be easily seen.

The following key to the species noted above may be useful to those who wish to identify their specimens:

Key to the males of the known Philippine species of the genus Musca.

1. Small or medium-sized species with four thoracic stripes........................ 2.
   Medium-sized species with only two thoracic stripes................................ 6.
   Large species with four thoracic stripes.. 7.
2. Small species. Thorax greenish gray with four moderately broad, black thoracic stripes tending to unite behind the suture. Adbomen orange with well-marked gray pollinosity; apparent first segment dark brown or nearly so.. **M. conducens** Patton.
   Medium-sized species. Thorax grayish or blackish.................................. 3.
3. Thorax grayish with four either broad or narrow black stripes. Eyes well separated .... 4.
   Thorax grayish or greenish, with four narrower stripes. Eyes almost meeting in the middle line.. 5.
   Thorax blackish with four broad black stripes, not easily seen. Abdomen orange without any markings.............................. **M. ventrosa** Wiedemann.
4. Abdomen light orange; apparent first segment narrowly black anteriorly; apparent third segment mainly orange..................... **M. nebulo** Fabricius.
   Abdomen darker orange; apparent first segment with broader black band; apparent third segment mainly black........... **M. vicina** Macquart.
   Abdomen olive green; apparent first segment black anteriorly, remainder grayish green; apparent second segment grayish green with a median narrow black stripe; apparent third segment with an anterior median black spot.. **M. crassirostris** Stein.

5. Thorax dark gray, inner thoracic stripes very narrow before the suture. Abdomen dark orange; apparent first segment dark; apparent third and fourth segments blackish.. **M. craggi Patton.**
   Thorax greenish gray, inner stripes not markedly narrow in front of the suture. Abdomen bright orange; apparent first segment darker anteriorly; apparent second with a narrow median stripe.
   M. planiceps Wiedemann.
6. Thorax gray with two broad black stripes. Abdomen orange; apparent first segment either dark or light brown; apparent third and fourth segments with a median black stripe and admedian and marginal silvery spots. Eyes well separated..................... **M. sorbens Wiedemann.**
   Thorax bluish gray with two broad black stripes. Abdomen dark orange; apparent first segment black; other two segments similar to those of *sorbens*. Eyes almost meeting in the middle line.
   M. vetustissima Walker.
7. Large species with dark gray thorax and well-marked broad black stripes. Abdomen brown with silvery and black stripes. Squamæ with long black hairs on middle and posterior part of upper surface. Eyes widely separated.. **M. inferior Stein.**
   Large species; thorax gray with four broad black stripes. Abdomen dark orange with dark stripes and silvery spots. Squamæ bare on upper surface. Eyes meeting in middle line......... **M. bakeri sp. nov.**

Key to the females of the known Philippine species of the genus Musca.

1. Small or medium-sized species with four thoracic stripes......................... 2.
   Medium-sized species with only two thoracic stripes................................. 6.
   Large species with four thoracic stripes.. 7.
2. Small species. Thorax light gray with four comparatively narrow black stripes, well separated. Abdomen dark gray with bands and stripes; apparent first segment black; apparent second segment with a basal black band of varying width.................... **M. conducens Patton.**
   Medium-sized species. Thorax grayish or blackish................................. 3.
3. Thorax dark gray with four broad black stripes.. 4.
   Thorax lighter gray with four narrower black stripes............................. 5.
4. Abdomen dark brown; apparent first segment black or dark brown anteriorly .... **M. vicina Macquart.**
   Abdomen light orange; apparent first segment also light orange; silvery stripes and spots on remaining segments well marked.
   M. nebulo Fabricius.
5. Inner thoracic stripes in front of suture narrowing toward the head. Abdomen bright orange; apparent first segment black; apparent second segment with a broad median black stripe and a broad black basal band.
   M. craggi Patton.
   Inner thoracic stripes not markedly narrower, if at all, than the outer. Abdomen light orange with well-marked yellow pollinosity.
   M. planiceps Wiedemann.
   Inner thoracic stripes a little narrower than the outer. Abdomen olive green; apparent first segment black anteriorly; apparent second segment with an anterior narrow black band and a narrow median black stripe.. **M. crassirostris Stein.**

6. Thorax gray with two black stripes, separated before the suture. Abdomen blackish gray with black bands and stripes. **M. sorbens** Wiedemann.

   Thorax bluish gray with two black stripes also separated before the suture. Abdomen bluish gray with black bands and stripes. **M. vetustissima** Walker.

7. Large species with dark gray thorax and well-marked black stripes. Abdomen brown with silvery and black stripes and black bands. Squamæ hairy above as in male.................................... **M. inferior** Stein.

   Large species with dark gray thorax and black stripes. Abdomen dark gray with stripes and bands. Squamæ bare............. **M. bakeri** sp. nov.

I have not been able to recognize the species *Musca favillacea* Walker and there is no type in the British Museum.

In concluding these notes I wish to take the opportunity of thanking Professor Bezzi for allowing me to study this very interesting collection of species of *Musca*. I will be glad to examine any further specimens of species of this genus from these Islands, and any notes relating to the habits of these species will be welcome.

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A NEW ORIENTAL SPECIES OF THE GENUS MUSCA

WITH A NOTE ON THE OCCURRENCE OF MUSCA DASYOPS STEIN IN CHINA AND A REVISED LIST OF THE ORIENTAL SPECIES OF THE GENUS MUSCA LINNÆUS

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In a large collection of Muscidæ from Java, Amboina, Borneo, and Honolulu recently sent me by Mr. J. F. Illingworth there are four specimens of a species of *Musca* which I believe is new to science. It is described below under the name *Musca illingworthi,* in honor of Mr. Illingworth, who has done much to advance our knowledge of the higher Diptera of the Oriental and Australasian Regions.

Musca illingworthi sp. nov.

Male.—Average length of two specimens, 7.5 millimeters. Eyes bare and nearly meeting in the middle line; frons a narrow black line, pinched in the middle; parafrontals, parafacials, and cheeks silvery; third antennal segment mouse gray; palps black and proboscis normal.

Thorax, ground color grayish blue with four broad black stripes meeting at the anterior end of the thorax and not interrupted at the suture; scutellum black in the middle and bluish gray at the sides. Two well-marked presutural dorsocentral bristles, presutural acrostical bristles wanting. Abdomen with apparent first segment dark brown or black anteriorly and at the sides, and a rather diffuse dark brown patch in the middle line, which in one specimen forms a partial dark basal band; the anterolateral and ventral sides of the tergite dark orange; apparent second segment with a broad median black stripe widening out anteriorly, and in the darker specimen fusing with the dark patch on the postero-median area of the first tergite; in addition, there is a broad silvery stripe on each side of it, and a large silvery spot at the extreme margin of the tergite; the intervening space is dark orange. The apparent third and fourth segments are similar to the second, the admedian brown stripes tending to form a narrow dark posterior

band on segment three, which is well marked on the ventral side of the tergite. Sternites dark orange. Wings with four small bristles on the radial root vein, but as they are not in very good preservation it is not possible to be sure of the number; as some of them have certainly fallen off; vein R_{4+5} with small bristles on its ventral side, extending well beyond the radiomedial cross vein. Legs black. Squamæ yellowish.

Female.—Average length of two specimens, 7 millimeters. Frons comparatively narrow, about half the width of the eye, and narrowest at the vertex, the orbital margins converging toward it. Frontal stripe about one-third the width of eye, sides slightly convex. Parafrontals gray, each about one-third the width of the frontal stripe and with a single row of small bristles; parafacials and cheeks silvery gray, edges of epistomum black. Antennæ, palps, and proboscis similar to those of male.

Thorax very similar to that of the male, presutural portion of outer stripes broad and more convex externally. Scutellum grayer at the sides than in the male.

Abdomen with apparent first segment similar to that of the male, but, if anything, the basal black band broader; apparent second segment with a narrower median dark brown stripe, the stripes adjacent to it and the marginal spots yellower, the admedian brown stripes broader, more triangular in shape and extending along the lower border, forming a posterior band interrupted a little in the middle. Apparent third and fourth segments similar, the admedian brown stripes narrower and the basal band on segment three more complete. Sternites as in the male. Legs and wing similar to those of the male.

The four specimens were collected at Buitenzorg, Java, and the types will eventually be returned to Mr. Illingworth, Honolulu, the cotypes remaining in my collection for further study.

I believe this is the species described by Stein,[1] without a name, from Samarang and Batavia. He refers to it again [2] under the name *Musca lusoria* Wiedemann, noting that it has small bristles all along the ventral side of vein R_{4+5} as in the true *lusoria*. But, as Villeneuve has already pointed out, this is not a character peculiar to *lusoria* but is common to many of the species of this group. Stein's description agrees very

[1] Neue Javanische Anthomyiden, Tijd. voor Entomol. 52 (1909).

[2] Neue Africanische Anthomyiden, Ann. Hist. Nat. Mus. Nat. Hung. 11 (1913).

well with this species I have before me, especially in the character of the short, wide abdomen, particularly of the female.

Musca illingworthi belongs to my Group II of the Genus *Musca* and, excluding the strictly Indian species, I know only two other Oriental species with which it may be confused; namely, *Musca bakeri* Patton,[3] from the Philippines, and *Musca hervei* Villeneuve, from southern China. It can be distinguished from the former by noting the following characters: In the male of *bakeri* the apparent first abdominal segment is either entirely black or there is a narrow posterior brown band; in *illingworthi* the segment is never—at least in the two specimens—entirely black, and the median posterior dark patch is more extensive, forming a band. The second segment in *bakeri* is lighter brown, the marginal silvery spot much smaller and the admedian area not nearly so dark; in *illingworthi* the segment is darker and the admedian brown stripe is pronounced and very dark. These differences are noticeable in the two other segments. The sternites of *bakeri* are black or dark brown, while in *illingworthi* they are light brown. The females are easily distinguished. The female of *bakeri* is a grayish fly, the abdomen in particular having a grayish white checkered appearance; the female *illingworthi*, on the other hand, is similar to the male, and the abdomen is dark brown.

In the British Museum collection I found several males of *Musca bakeri* from Singapore, and a male and two females from Kajoe Taman, Sumatra, showing that this species may quite well be found in the same localities as *Musca illingworthi*. I hope later to have an opportunity of examining the species referred to by Stein; these specimens are, I understand, now in Amsterdam.

Musca illingworthi can be distinguished at once from *Musca hervei* by noting that in the latter the small bristles on the ventral side of vein R_{4+5} are strictly limited to the basal portion of the vein and do not reach or extend beyond the radiomedial cross vein. Further, the sternites and the ventral edges of the tergites in *hervei* are black, giving the appearance of a dark line inclosed in brackets.

In addition to *Musca illingworthi*, the collection contains a long series of both sexes of *Musca inferior* Stein, a very characteristic bloodsucking species belonging to my Group III; both sexes have long dark hairs on the upper surfaces of the squamæ.

[3] Antea 316.

There are also one female of *Musca senior-whitei* Patton, recently described from India (this is the first specimen I have seen from Buitenzorg, Java); one rather greasy male of what may be *Musca terrae reginae* Johnstone and Bancroft and a male of *Musca nebulo* Fabricius, both from Guadalcanar Island, Solomon Islands; and several specimens of *Musca vicina* from Java, Amboina, and Honolulu.

NOTE ON THE OCCURRENCE OF MUSCA DASYOPS STEIN IN CHINA

Recently during my visit to Prof. M. Bezzi at Turin, he very kindly gave me for description a male and a female of a species of *Musca* sent him by Professor Howard, from Canton, China. On comparing the female with the type and cotype of *Musca dasyops* Stein from Kilamandjaro, East Africa, recently sent to me by Doctor Kertesz for study, I find this Chinese species is identical with it. As Stein never saw the male, I here describe it as well as the female.

Musca dasyops Stein.

Male.—Length, 5.5 millimeters. Eyes densely hairy and almost meeting in the middle line; parafacials silvery; cheeks black. Third antennal segment mouse gray, arista black; palpi black and proboscis normal.

Thorax dark gray, and in some lights appearing almost black; but this specimen is not in good preservation, the thorax being greasy. It is very probable the markings are similar to those of the female (see below). The presutural dorsocentral bristles are poorly developed, especially the one just in front of the suture; presutural acrostical bristles are wanting. The scutellum is dark gray in the center and silvery at the sides.

Abdomen with apparent first segment dark brown; second segment with a broad dark median stripe, and broad anterior and posterior dark brown basal bands, which join each other at about the middle of the sides of the tergite, forming dark brown admedian stripes; the areas between the median stripe and these (the lateral ones) are silvery and appear as white spots; the margins of the tergite are silvery. The third segment is similarly marked, as is also the fourth; the ventral sides of the tergites are lighter brown, with silvery patches. Legs light brown. Wings and venation normal; squamæ brownish and halteres yellowish.

Female.—Length, 6 millimeters. Eyes minutely but thickly pubescent. Frons wide, almost equal to the width of the eye; frontal stripe black; parafrontals black, and equal to about half the width of the frontal stripe; parafrontal bristles long and consisting of three rows, forming a closely set group at vertex, as noted by Stein. Parafacials silvery; cheeks black. Third antennal segment dark brown; palpi black.

Thorax dark with two broad black stripes slightly divided before the suture; a well-marked silvery median stripe before the suture; humerus silvery.

Abdomen similar to that of male, except that the admedian stripes on the second segment are not complete and the silvery spots form a silvery median band. Wings, legs, squamæ, and halteres as in male.

Were it not that I have been able to compare the two Chinese specimens with the type and cotype of *Musca dasyops,* I should have hesitated to regard them as conspecific, especially when it is remembered that they are found in two widely separated areas. I have not seen *M. dasyops* from any part of India. The two specimens noted by Stein came from Kilamandjaro, East Africa, and Professor Bezzi gave me a female collected by Allaud and Jeannel in the forest region of Mount Kenya, at an altitude of 2,400 meters. Villeneuve has evidently seen fifty specimens including two males collected by these observers. The species is oviparous. I hope collectors in China and neighboring parts will look for this interesting species and observe its feeding and breeding habits.

REVISED LIST OF THE ORIENTAL SPECIES OF THE GENUS MUSCA LINNÆUS

In the following list all the types of the species marked with an asterisk have been examined by me, and the synonyms with a query before them are doubtful.

Musca domestica Linnæus.

Musca calleva Walker.*
Musca antiquissima Walker.*
Musca vicaria Walker.*
Musca pampasiana Bigot.*
Musca minor Macquart.*
Musca corvina Fabricius.
Musca ludifica Fabricius.

Musca umbraculata Fabricius.
? *Musca pellucens* Meigen.
? *Musca chiiensis* Macquart.
? *Musca lateralis* Macquart.
? *Musca aurifacies* R-D.
? *Musca riparia* R-D.
? *Musca campestris* R-D.
? *Musca stomoxidea* R-D.
? *Musca campicola* R-D.
? *Musca vagatoria* R-D.
? *Musca hottentota* R-D.
? *Musca vicina* R-D.
? *Musca campicola* R-D.
? *Musca rivulans* R-D.
Musca frontalis R-D.

Common in Kashmir and the large seaports of the Oriental Region, and possibly inland.

As would be expected, the common house fly *Musca domestica* Linnæus has been described many times. Wiedemann who studied Fabricius's collection at Kiel states it did not contain a single specimen of *M. domestica,* labeled as such by Fabricius, but that *corvina* Fabricius, *ludifica* Fabricius, and *umbraculata* Fabricius are nothing more than *domestica* Linnæus. As Wiedemann must have examined the types of these species and notes that the specimen of *corvina* and *umbraculata* labeled by Fabricius at Copenhagen are *domestica,* we must accept these determinations as final, and remove the names *corvina* and *ludifica* from the synonomy of *Musca autumnalis* de Geer. The remaining synonyms must be regarded in the nature of mere guesses at the truth; the types, except that of *frontalis,* do not exist and it is quite impossible to determine the species.

Musca vicina Macquart.*

Musca flavinervis Thomson.*
Musca flavifacies Bigot.*
Musca flavipennis Bigot.*
Musca atrifrons Bigot.*
? *Musca biseta* Hough.
? *Musca divaricata* Awati.
? *Musca analis* Macquart.
? *Musca sanctae-helenae* Macquart.
? *Musca basilaris* Macquart.
? *Musca frontalis* Macquart (nec Rondani).
? *Musca senegalensis* Macquart.
? *Musca consanguinea* Rondani.
? *Musca divaricata* Awati.

One of the widely distributed house flies of the Oriental Region.

As already pointed out, I have examined the type of *Musca vicina* Macquart and find it is the species which is very like the typical *domestica,* but differing in that the male has a much narrower front—about half the width of the male of *domestica.* I have also examined the types of *flavinervis, flavifacies, flavipennis,* and *atrifrons,* and note that they are this species. I hope soon to have an opportunity of examining the type of *biseta* Hough. The remaining synonyms are given with a mark of interrogation before them, as I am unable to determine them from the descriptions of their authors. Stein has several times referred to this species of *Musca,* regarding it as a narrow-fronted *domestica.*

Musca nebulo Fabricius.

Musca determinata Walker (nec Patton).*
? Musca multispina Awati.

The other common house fly of the Oriental Region.

Unfortunately, the type of this important fly has shared the fate of the rest of the collection of Diptera belonging to Fabricius at Kiel; but, as Wiedemann examined this type when it was still intact and redescribed it very fully, I have no hesitation in accepting as final Major Austen's determination given me many years ago. Wiedemann says: "Hinterleib gelblich durchscheinend, in gewisser Richtung weisslich fast gewürfelt, mit schwarzer, den vierten Abschnitt nicht erreichender Strieme," which agrees exactly with the characters of the abdomen of this species.

Musca yerburyi Patton.*

Musca incerta Patton (nec Walker).*

Common in southern India, Ceylon, and Burma.

Shortly after describing this species under the name *incerta,* I found that the name was preoccupied by *Musca incerta* Walker, so I here take the opportunity of changing the name to *yerburyi* in honor of Colonel Yerbury who has done so much to advance our knowledge of the Oriental and, particularly, the Cingalese species of the genus *Musca.* I have not seen this species in any of the collections I examined in the continental museums. So far, it is now known only from India.

Musca sorbens Wiedemann.*

Musca humilis Wiedemann.*
Musca latifrons Wiedemann.*
Musca mediana Wiedemann.*
Musca spectanda Wiedemann.*
Musca angustifrons Thomson.*
Musca bivittata Thomson.*
Musca sordissima Walker.*
Musca eutentiata Bigot.*
Musca scapularis Rondani.
Musca conducens Patton (nec Walker).*
Musca praecox Patton (nec Walker).*
? *Musca promisca* Awati.

The well-known and widely distributed, two-striped, gray, tropical house and camp fly.

It is interesting to note that the well-known and common *Musca humilis* was described no less than five times by such a careful worker as Wiedemann; *sorbens* is now the oldest name. *Musca sorbens,* No. 58, a female, came from Sierra Leone; *M. humilis,* No. 59, a male, came from India; *M. spectanda,* No. 61, a male, came from Sierra Leone; *M. latifrons,* No. 16,[4] a female, came from Macao; and *M. mediana,* No. 18 in the Appendix, a male, came from China.

Wiedemann says the specimens of *mediana* from which he wrote his description are in Trentepohl's and his collections. The former, at Copenhagen, is however not *sorbens* but the species long known to me as *Musca convexifrons* Thomson, and which I now know is *Musca xanthomelas* Wiedemann. The specimen in von Winthem's collection at Vienna, which I now have before me, has a small piece of red paper indicating that Wiedemann meant it to be his type, and so I interpret it; it is a typical specimen of the female *sorbens*.

Most dipterists who have attempted to determine *Musca spectanda* from Wiedemann's description alone have gone wide of the mark; and I must admit that, though I have read the description of *spectanda* many times, I never recognized in it *humilis,* or, as it should now be called, *sorbens.* This is a very good example of the great importance of examining all the types of these older authors. I have already corrected a mistake made in interpreting *Musca conducens* Walker and *M. praecox* Walker as *sorbens;* both are, however, quite another species (see below).

[4] Appendix to Volume II, Aussereuropäische zweiflügelige Insecten.

Musca vetustissima Walker.*

Musca pumila Patton (nec Macquart).
Musca minor Patton (nec Macquart).
Musca humilis Stein et auctores (nec Wiedemann).
Musca corvina Froggatt (nec Fabricius).
Musca niveisquama Thomson.*

A common Oriental species.

As I have not been able to find a type of *Musca pumila* Macquart, and cannot be certain of the identity of this species from Macquart's meager description, I propose dropping this name. I am, however, certain of the identity of *vetustissima* Walker and, therefore, propose using this name in the future. *Musca niveisquama,* the type of which I have seen at Copenhagen, is also this species. Both Stein and Austen evidently had what were considered to be cotypes sent them, but which are not conspecific with the type which is clearly labeled so by Thomson.

Musca tempestiva Fallen.

? *Musca curpea* Macquart.
? *Musca nana* Meigen.

Found in Kashmir.

I have only seen this species from Kashmir. It can very easily be confused with *Musca conducens.*

Musca vitripennis Meigen.

? *Musca osiris* Wiedemann.
? *Musca sugillatrix* R-D.
? *Musca phasiaformis* Meigen.

Found in Kashmir.

I hope to see Wiedemann's type of *osiris* later, and only provisionally give it as a synonym for *vitripennis.*

Musca ventrosa Wiedemann.*

Musca xanthomela Walker.*
Musca angustifrons Thomson.
Musca pungoana Karsch.*
? *Musca kasauliensis* Awati.

Widely distributed in the Oriental Region.

Musca craggi Patton.*

Common in southern India, Ceylon, and the Philippine Islands.

This rather small species is easily recognized by its bluish thorax, and the narrow presutural portion of the inner stripes.

Musca villeneuvi Patton.*

From southern India.

A smallish species with only two thoracic stripes; the puparium is white.

Musca lucens Villeneuve.*

Recorded from Kandy, Ceylon.

This small species was recently described by Villeneuve from Kandy, Ceylon. I found one male collected by Colonel Yerbury at Trincomali (January 13, 1892), and two females, one from Haragam (June 1, 1892) and the other from Trincomali, Ceylon, (July 20, 1890) in his collection at the British Museum. As Villeneuve has only described the male, I give a short description of the female, as follows:

Female.—Frons almost the width of eye; frontal stripe about one-third the width of eye; parafrontal bristles in two rows; parafacials and cheeks silvery; vertex steel blue. Antennæ and palps dark gray. Thorax bluish white with two broad black stripes; in one specimen the stripes are a little divided before the suture, giving the appearance of four stripes; sides of thorax grayish white. Scutellum light brown in the middle and bluish gray at the sides. Abdomen with apparent first segment light brown; second segment similar, with some bluish pollinosity; third segment similar; the fourth is brownish in the center and silvery at the sides. Legs light brown.

The male of this species can quite easily be confused with the male of *Musca conducens;* however, it has only two thoracic stripes, while *conducens* has four, which only tend to unite. The females are quite distinct.

Musca conducens Walker.*

Musca praecox Walker.*
Musca humilis Patton (nec Wiedemann).
Pristirhynchomyia lineata Brunetti.

A widely distributed Oriental species.

This small species is of great interest as it possesses well-developed prestomal teeth, which are capable of scratching off a small clot or scab. Though I have not seen the type of *Pristirhynchomyia lineata* Brunetti, which is in the Indian Museum, I have specimens, labeled by Mr. Brunetti. The female can quite easily be mistaken for the female of *tempestiva.*

Musca xanthomelas Wiedemann.*

Musca albomaculata Villenueve, Patton (nec Macquart).*
Musca dorsomaculata Villeneuve, Patton (nec Macquart).*
Musca convexifrons Bezzi, Patton (nec Thomson).

A common Indian species.

This species has long been confused with *convexifrons* Thomson, and recently with *albomaculata* Macquart and *dorsomaculata* Macquart. The type of *xanthomelas,* a female in Westermann's collection at Copenhagen, though in bad preservation, is a typical specimen of this Indian species; it was collected in Java from where it has not since been recorded; it has a white puparium.

Musca albina Wiedemann.*

Musca speculifera Bezzi.*
Musca beckeri Schnable.

Found in Ceylon and Baluchistan, in the Oriental Region.

Colonel Yerbury's collection contains one female *albina* from Trincomali (October 1, 1890) and a male from Mahagasy (November 30, 1890). The male of this interesting species has not been described, but Professor Bezzi tells me he has recently prepared a description of it as well as of the male of *lucidula* Loew (which closely simulates it) from material from Cairo, where both species are not uncommon. He is erecting a new subgenus for *albina,* in both sexes of which sternopleural bristles are wanting. Except the type, which is a female, from India, I have seen only one other specimen from Baluchistan in the Indian Museum collection, which I now have for study. Colonel Yerbury is to be congratulated on securing these specimens, especially the male, from Ceylon. I hope collectors in the Oriental Region will look for this interesting species. It is a very whitish fly, the female particularly so, with a very broad frons and a narrow black frontal stripe. The thorax of the male is glossy black, the humeri are white; the abdomen is light orange with spots and stripes, as in *lucidula.*

Musca gibsoni Patton and Cragg.*

? *Musca latiparafrons* Awati.

Common in many parts of India and Ceylon.

I have not seen this species from anywhere outside the Indian area; in the male the eyes are minutely pubescent. The types are in the Indian Museum, but I have many cotypes in my collection.

Musca pattoni Austen.*

? Musca spinosa Awati.

I have not seen this species from outside the Indian area.

Musca spinohumera Awati.

I am not sure of the identity of this species. Mr. Senior-White has tried, on more than one occasion, to get the types of Mr. Awati's species, but has so far failed. It is a great pity these have not been deposited in the Indian Museum.

Musca prashadi Patton.*

From Kashmir.

Musca bezzii Patton and Cragg.*

? Musca pilosa Awati.

Widely distributed in India.

I have not seen this species from any other part of the Oriental Region. It appears to be strictly Indian, and is mainly a hill species. The types are in the Indian Museum, the cotypes in my collection.

Musca bakeri Patton.*

From the Philippine Islands.

Musca hervei Villeneuve.*

From southern China.

Musca illingworthi Patton.*

From Java and neighboring parts.

Musca convexifrons Thomson.*

From southern China.

This species is common in Australia.

Musca dasyops Stein.*

From southern China.

Musca senior-whitei Patton.*

Common in Bengal and Bezwada, India.

I have noted above a single female in Mr. Illingworth's collection.

Musca inferior Stein.

Philaematomyia gurneyi Patton and Cragg.*

Widely distributed in the Oriental Region.

The types of *P. gurneyi* are in the Indian Museum.

Musca planiceps Wiedemann.*

Musca cingalaisina Bigot.*
Musca pollinosa Stein.
Philaematomyia indica Awati.

Widely distributed in the Oriental Region.

The type of *Musca planiceps* from Java is in Westermann's collection at Copenhagen. Though I have not seen Stein's types of *Musca pollinosa* I have no doubt that it is this species.

Musca crassirostris Stein.

Musca modesta de Meijere.
Musca insignis Austen.*

Widely distributed in the Oriental Region.

I quite expected to find this species either in Westermann's collection at Copenhagen or in that of von Winthem at Vienna, but as I was unable to see the latter when at Vienna, Doctor Zerny has kindly sent me the types of Wiedemann's species of *Musca.* I find this species is represented by one female, labeled *inconstans* in Wiedemann's handwriting; on looking for this name in Volume 2 of his celebrated work, I find the name without an index number and, unfortunately, it does not appear to have been described; so the name cannot be used. The specimen in question, a female, is from India. With Professor Bezzi I came to the conclusion that *Musca modesta* is this species, and Professor de Meijere tells me this is the case. I hope later to see the types of this species as well as those of *crassirostris.*

From the above list it will be seen that I have examined fifty-three types. I hope in due course to publish a paper on the Oriental species in collaboration with Mr. Senior-White, in which all the above species will be fully described and illustrated, and a key given for their identification. I will be glad to have any material from southern China, Formosa, and neighboring parts, so as to make this paper as nearly complete as possible. Larvæ of any species with adults bred from them will be most welcome.

In conclusion, I wish to take this opportunity of thanking Mr. Illingworth for sending me this valuable collection for study.

THE COMPOSITION OF CASHEW-NUT OIL

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INTRODUCTION

Cashew-nut oil, commonly called kasui in Manila, is obtained from the seed of *Anacardium occidentale,* a small tree with a trunk that is usually small and crooked. This species occurs in the East and West Indies and was introduced into the Philippines from America at an early date. It is widely distributed in the Philippines and is cultivated in towns and on farms and runs wild in old clearings. It has a large, yellow, pear-shaped fruit, with a kidney-shaped seed attached to one end. Both the fruit and the seed are edible, the fruit raw and the kernel raw or roasted. The roasted kernels are used to make a very savory nut candy.

According to Watt [1] two oils are obtained from the seeds of *Anacardium occidentale.*

The pressed kernels yield an oil, the finest quality of which is equal to almond oil; and the shell of the nut yields an acrid fluid, called "cardol" which is efficacious for protecting carved wood, books, etc., against white ants. Cashew-nut oil obtained from the pressed kernels is an edible oil which has a somewhat sweet taste and yellow color. The keeping quality of the oil is very good, as shown by the fact that a sample stored for five months had no rancid taste or odor, and the acid value was only 1.45.

Lewkowitsch [2] states that the yield of oil from the kernels is 47.2 per cent; but he gives no data concerning the composition of the oil.

[1] Watt, G., The Commercial Products of India (1908).

[2] Lewkowitsch, J., Oils, Fats, and Waxes 2 (1915) 404.

SAMPLE

The sample of oil used in this investigation was obtained from cashew-nut seeds which were purchased in the various markets in Manila. Six boys were set to work to separate the kernels from the shells. The seeds were cut in half with a knife and the kernel was taken out of the shell, after which the brown skin surrounding the kernel was removed. The kernels were ground into a meal, placed in a small press, and the oil separated from the oil cake. The oil was then filtered and stored in glass-stoppered bottles.

The analysis [3] of the oil cake is given in Table 1.

TABLE 1.—*Analysis of cashew-nut oil cake.*

Constituents.	Per cent.
Oil	16.12
Moisture	2.37
Ash	3.94
Protein	31.67
Nitrogen	5.70
Crude fiber	0.44
Carbohydrates	45.46

CONSTANTS

The more-important constants of cashew-nut oil are given in Table 2.

TABLE 2.—*Constants of cashew-nut oil.*

Specific gravity at $\frac{26.6^\circ}{4^\circ}$	0.9105
Refractive index at 30° C.	1.4665
Iodine value (Hübl)	85.20
Saponification value	187.00
Acid value	1.45
Unsaponifiable matter (per cent)	[a] 1.47

[a] Iodine value, 94.55

In investigating the composition of cashew-nut oil the saturated and unsaturated acids, which are present as glycerides in the oil, were separated by the lead-salt-ether method.[4] The unsaturated acids were determined by means of the bromo-derivative method.[5] The saturated acids were converted into their

[3] Analysis made by Miss C. M. Spooner, of the Bureau of Science, Manila.

[4] Lewkowitsch, J., Chemical Technology and Analysis of Oils, Fats, and Waxes 1 (1921) 556.

[5] Ibid (1921) 585.

methyl esters,[6] which were fractionally distilled. The composition of the saturated acids was estimated by calculating the data obtained from the methyl esters.

SEPARATION OF SATURATED AND UNSATURATED ACIDS

The lead-salt-ether method does not give complete separation of saturated and unsaturated acids, since the saturated acids are always contaminated by a small quantity of unsaturated acids, as shown by the iodine value of the saturated acids. The unsaturated acids are also likely to be contaminated with a small quantity of saturated acids, but this error can usually be reduced to an unappreciable amount by not washing very thoroughly with ether the lead salts of the saturated acids.[7]

In separating the saturated and unsaturated acids by the lead-salt-ether method the unsaponifiable matter originally present in the oil goes with the unsaturated acids.[8] The percentage of impure unsaturated acids, as determined, should therefore be corrected, not only for the small amount of unsaturated acids present in the saturated acids, but also for the unsaponifiable matter which they contain.

The results of separating the saturated and unsaturated acids of cashew-nut oil by the lead-salt-ether method are given in Table 3.

TABLE 3.—*Separation of saturated and unsaturated acids of cashew-nut oil by the lead-salt-ether method.*

	Per cent.
Impure saturated acids (determined)	[a] 23.10
Unsaturated acids and unsaponifiable matter (determined)	[b] 72.31
Total	95.41

[a] Iodine value (Hübl) 26.79. [b] Iodine value (Hübl) 94.18.

[6] Jamieson, G. S., and Baughman, W. F., Journ. Am. Chem. Soc. 42 (1920) 1200.

[7] Baughman, W. F., Brauns, D., and Jamieson, G. S., Journ. Am. Chem. Soc. 42 (1920) 2398.

[8] Lewkowitsch, J., Chemical Technology and Analysis of Oils, Fats, and Waxes 1 (1921) 584; Baughman, W. F., and Jamieson, G. S., Journ. Am. Chem. Soc. 43 (1921) 2679.

TABLE 3.—*Separation of saturated and unsaturated acids of cashew-nut oil by the lead-salt-ether method*—Continued.

Unsaponifiable matter (calculated) in the total determined percentage of saturated acids, unsaturated acids, and unsaponifiable matter (95.41)	1.94
Pure unsaturated acids corrected for unsaponifiable matter	70.37
Unsaturated acids present in the impure saturated acids	6.57
Pure saturated acids corrected for unsaturated acids (calculated)	16.53
Pure unsaturated acids corrected for unsaponifiable matter and for the unsaturated acids present in the saturated acids	76.94

The percentage of unsaponifiable matter (1.47, Table 2) originally present in the oil is equivalent to 1.94 per cent in the total percentage (95.41, Table 3) of the impure saturated acids, unsaturated acids, and unsaponifiable matter:

$$\frac{(72.31 + 23.10) \times 1.47}{72.31} = 1.94.$$

The percentage of pure unsaturated acids corrected for unsaponifiable matter is, therefore, 70.37:

$$95.41 - (23.10 + 1.94) = 70.37.$$

The impure saturated acids separated by the lead-salt-ether method had an iodine value of 26.79. The unsaturated acids present as contamination in the impure saturated acids was 6.57 per cent:

$$\frac{23.10 \times 26.79}{94.18} = 6.57.$$

The percentage of pure saturated acids was 23.10 — 6.57, or 16.53. The percentage of the total pure unsaturated acids corrected for unsaponifiable matter and for the unsaturated acids (6.57 per cent) which were present as contamination in the impure saturated acids was 70.37 + 6.57, or 76.94.

UNSATURATED ACIDS

The impure unsaturated acids separated by the lead-salt-ether method were determined by means of the bromo-derivative method, which is used to separate the various unsaturated acids from each other. The sample of unsaturated acids and unsaponifiable matter (1.3172 grams) used for preparing the bromo-derivatives consisted of 0.0353 gram of unsaponifiable matter and 1.2819 grams of pure unsaturated acids. The bro-

mine addition products were prepared by dissolving the unsaturated acids and unsaponifiable matter in ether; the ethereal solution was cooled to a temperature of − 10° and bromine added slowly, after which the solution was allowed to stand about three hours at − 10°. No crystals of linolenic hexabromide, which is insoluble in ether, were obtained. This indicated that cashew-nut oil contained no linolenic glyceride. The ethereal solution was then treated with 10 per cent sodium thiosulphate solution to remove the excess of bromine. This treatment was repeated to remove the last traces of bromine, after which the separated ethereal solution was dehydrated with anhydrous sodium sulphate, filtered, and distilled to eliminate the ether. The residue was then treated with petroleum ether (boiling point, 35° to 55°) and heated (reflux) for about a half hour. The petroleum ether solution was then cooled and allowed to stand several hours. No crystals of linolic tetrabromide were obtained. The solution was concentrated by distilling to a volume of about 200 cubic centimeters, cooled, and allowed to stand several hours but, still, the tetrabromide did not crystallize. This indicated that, if the oil contained linolic glyceride, the percentage was probably small. The petroleum ether solution was concentrated to a volume of about 100 cubic centimeters, transferred to a small distilling flask and the petroleum ether eliminated by distilling under diminished pressure. The impure residue (2.0841 grams) consisted of brominated unsaturated acids and brominated unsaponifiable matter. The bromine content (36.70 per cent) of the impure residue was determined by boiling 0.5368 gram with about 0.5 gram of solid silver nitrate and 30 cubic centimeters of pure concentrated nitric acid. The precipitated silver bromide (0.4630 gram) was then collected on a Gooch filter.

The iodine value of the unsaponifiable matter in the oil was 94.55. This is equivalent to a bromine value of 59.56 and corresponds to 0.0086 gram of bromine in the unsaponifiable matter contained in the sample of impure residue used for the bromide analysis. The pure brominated unsaturated acids (2.0282 grams) in the total impure residue (2.0841 grams) obtained from the preparation of bromo-derivatives had a calculated bromine content of 36.06 per cent. The bromine content of oleic dibromide is 36.18 per cent. Since the calculated percentage of bromine in the brominated unsaturated acids was 36.06, the unsaturated acids consist of oleic acid only.

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The percentage of unsaturated acids, separated by the lead-salt-ether method, corrected for unsaponifiable matter and for the amount of unsaturated acids present in the saturated acids, was 76.94 (Table 3), which is equivalent to 80.40 per cent of oleic glyceride originally present in the oil. The data obtained by the analysis of the bromo-derivatives and a summary of the calculated results are given in Table 4.

TABLE 4.—*Analysis of unsaturated acids (bromo-derivative method).*

	Grams.	Per cent.
Sample of unsaturated acids containing unsaponifiable matter	1.3172	....
Unsaponifiable matter in the mixture of unsaturated acids and unsaponifiable matter	0.0353	2.68
Pure unsaturated acids in mixture of unsaturated acids and unsaponifiable matter	1.2819	....
Linolenic hexabromide insoluble in ether	....	....
Linolic tetrabromide insoluble in petroleum ether	....	....
Impure residue (brominated unsaturated acids and brominated unsaponifiable matter) determined	2.0841	....
Brominated unsaponifiable matter in impure residue (calculated)	0.0559	2.68
Unsaponifiable matter in sample of impure residue (0.5368 gram) used for bromide analysis	0.0144	....
Bromine in the unsaponifiable matter (iodine No. 94.55) contained in sample of residue used for bromide analysis	0.0086	....
Bromine in impure residue analyzed (silver bromide, 0.4630 gram)	0.1970	36.70
Bromine in pure brominated unsaturated acids contained in sample of impure residue analyzed	0.1884	....
Bromine in pure brominated unsaturated acids contained in total impure residue	0.7314	....
Pure brominated unsaturated acids (bromine content, 36.06 per cent) in total impure residue	2.0282	....
Oleic acid equivalent to dibromide	1.2940	....
Unsaturated acids separated by lead-salt-ether method (corrected)	....	76.94
Oleic glyceride in oil	....	80.40

The calculated iodine value of the mixture of unsaturated acids and unsaponifiable matter is 90.19, which agrees fairly well with the determined value, 94.18 (Table 3).

SATURATED ACIDS

The impure saturated acids were converted into their methyl esters by dissolving the acids in methyl alcohol and saturating the solution with dry hydrogen chloride which was prepared by treating fused ammonium chloride with sulphuric acid and passing the gas through sulphuric acid. The mixture was then heated on a water bath (reflux) for fifteen hours, after which it was treated with water and the ester layer separated. The esters were dissolved in ether and the ethereal solution was washed with sodium carbonate solution and afterwards with water. The ethereal solution was then dehydrated with anhydrous sodium sulphate, filtered, and the ether removed by distilling. The impure esters, which were yellow, were distilled under diminished pressure. A preliminary distillation at about 15 millimeters pressure was made to obtain the pure colorless esters and eliminate the dark-colored impurities which were formed as by-products in the esterification process. The colorless esters were then redistilled. Data on the distillation of the esters are given in Table 5.

TABLE 5.—*Distillation of the methyl esters of the saturated acids.*

[52.6666 grams of esters distilled; pressure, 15 millimeters.]

Distillation.	Distillate.	Residue.	Temperature.
	g.	*g.*	°*C.*
I	48.6132	4.0534	211–215
II	45.8184	2.7948	212–214

As a result of the first distillation, 52.6666 grams of esters gave 48.6132 grams of distillate and 4.0534 grams of brown residue. The temperature varied from about 211° to 215°, and the pressure was about 15 millimeters. The colorless distillate was then redistilled, yielding 45.8184 grams of a second distillate and 2.7948 grams of second residue which had a light yellow color. During the second distillation the esters distilled over at a temperature of about 212° to 214°. Since at the beginning of the distillation the esters were colorless and the residue which remained after the distillation was light yellow, it would seem that the esters were partially decomposed during the distillation. At a pressure of 15 millimeters methyl oleate distills at 212° and methyl stearate at 214°. The results ob-

tained indicate that the pure esters consist almost entirely of a mixture of the methyl esters of oleic and stearic acids and that the saturated acids from which the esters were obtained consist of stearic acid only.

The percentage of saturated acids, separated by the lead-salt-ether method, corrected for the unsaturated acids which they contained, was 16.53 (Table 3) which is equivalent to 17.27 per cent of stearic glyceride originally present in the oil.

The residues obtained in distilling the methyl esters were not taken into account in calculating the composition of the saturated acids. In distilling the esters a slight decomposition appeared to occur, and it would seem that data obtained by analyzing the impure residues would not represent exactly the properties of the pure esters. Possibly the residues contained other esters in addition to those recorded; but, considering the temperatures and the manner in which the esters distilled, this would seem to be unlikely.

SUMMARY

Cashew-nut oil is an edible oil which has good keeping qualities and the following composition:

Constituents.	Per cent.
Oleic glyceride	80.4
Stearic glyceride	17.3
Unsaponifiable matter	1.5
Total	99.2

We wish to express our thanks and appreciation to Mr. Arthur F. Fischer, director of the Philippine Bureau of Forestry, for the material used in this investigation and the assistance he has kindly given.

THE JASSOIDEA RELATED TO THE STENOCOTIDÆ WITH SPECIAL REFERENCE TO MALAYAN SPECIES

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FIVE PLATES

In another paper[1] I presented a study of some remarkable, isolated, largely palæotropical jassoid types, which were brought together in the family Stenocotidæ sens. lat. A study of extensive, recently collected Malayan material, Australian material kindly furnished by Mr. F. Muir and Dr. J. F. Illingworth, Japanese material obtained from Prof. S. Matsumura, Indian material from the Zoölogical Survey of India, and Sumatran material from Mr. J. B. Corporaal strengthens the general conclusions reached in that paper, and makes possible the presentation of much more confirmative evidence and a better arrangement of the families and genera involved. This later and more extended study convinces me that the groups formerly proposed are natural ones, and that they are better distinguished and of higher grade than was formerly supposed.

Distant[2] refers to the above paper, and dismisses the whole matter by saying that he does "not propose to follow" the removal of *Signoretia* from the Tettigoniellidæ.[3] He does not explain how a genus having ocelli placed contiguous to the anterior border of the head can possibly be placed in the Tettigoniellidæ as that family is currently characterized—even in the Errhomenellini, in which the ocelli are located farther forward than in normal tettigoniellids, but still on the disk of the vertex and remote from the frontal suture; nor can he mention any true tettigoniellid in which the ocelli are visible in facial view, as they are in all of the insects placed in Stenocotidæ sens. lat. in the paper mentioned.

[1] Philip. Journ. Sci. § D 10 (1915) 189-200.

[2] Fauna Brit. India, Rhynch. 7 (1918) 12.

[3] Doctor Melichar, in litt. January, 1922, says: "*Signoretia* cannot possibly be placed in the Tettigoniellidæ and the separation by you is very correct."

Apparently following the post-Stålian and entirely erroneous disposition of *Signoretia,* Matsumura described as tettigoniellids the genera *Onukia* and *Oniella;* [4] but both of these are closely related to *Pythamus* and *Dryadomorpha,* and the position of their ocelli with the accompanying head structure is essentially similar to that in *Signoretia, Pythamus, Paropia,* and *Dryadomorpha. Oniella* shows some remarkable resemblances to *Balbillus,* the position of ocelli with accompanying structures being very similar.

Melichar evidently recognized the relationship of *Pythamus* and *Signoretia* since he placed them together, but in the Tettigoniellidæ.[5] Distant [6] leaves *Signoretia* near *Tettigoniella* but separates *Pythamus* as an unattached genus at the end of the series; [7] *Chudania,* a nearly related genus, he leaves unattached at the opposite end of the series.[8] Kirkaldy, in describing *Tortor* and *Dryadomorpha,* recognized that they were out of place in the phrynomorphine series. As previously stated, Stål correctly placed *Signoretia* near *Megophthalmus.*

In his first work above mentioned, Distant also refers to my suggestion of the very close relationship of *Preta* and *Signoretia,* expressing surprise in italics that at the same time differential characters should be given. Do not subgenera, also, have differential characters? In the present paper a new species of *Preta* is described that brings *Preta* and *Signoretia* still closer together and breaks down one of the conspicuous differences supposed to separate them.

This complex is composed of isolated and peculiar types that find no place in other series of jassoid insects, and yet they present fundamental anatomical similarities which indubitably indicate far closer relationship between them than with other Jassoidea. It is essentially an Old World group, though *Paropulopa* is reported from North America, and an entirely peculiar group (Koebeliidæ) occurs in the American Pacific coast states. It seems probable that a number of other aberrant African and Asian genera, scattered through the phrynomorphine and other series, should be removed to the neighborhood of the Stenocotidæ.

The history of the classification of the jassoid insects is that of most large groups, though no attempt has been made toward

[4] Annot. Zool. Japon. 8 [1] (1912) 44–46.

[5] Homop. Ceylon (1903) 161.

[6] Fauna Brit. India, Rhynch. 4 ((1908) 232.

[7] Op. cit. 203.

[8] Op. cit. 268.

development of a general system adapted to include the immense number of forms now in collections, or toward a general and much-needed revision of the genera of the world. We are still trying to use, to include all of the jassoid insects of the world, the very ancient and artificial system originally proposed for a few species formerly known in Europe. If the ocelli were on the disk of the crown, the insect was a tettigoniellid, if on the margin a jassid, and if on the face a bythoscopid; quite disregardful of the fact that the ocelli are on the vertex, morphologically speaking, in all of these groups. The utter impossibility of classifying these insects on an artificial one-character basis is very evident in every work that is published on new and little-known faunæ. There is little wonder that Distant could not place *Chudania* or *Pythamus* in any of the older families! Genera of the closest relationships have been placed in remote parts of the ancient "system," and genera of no fundamental relationship are thrown together. Superficial characters cannot be used for general grouping. General outlines of head and pronotum, head thick or thin, etc., are characters widely variable even within the same genus.

In the Nirvaniidæ, among insects of the closest relationship, strongly similar in color pattern and body form, the ocelli may be on the anterior surface of the crown (sometimes far from the margin), on the border between crown and face, or on the upper surface of the face below the border of the crown. Venation can only be used with many reservations. Many of the cross veins are very variable in position and often may be present or absent in the same species. To separate two genera because one has "four apical cells" and another "five apical cells," when it is well known that the subcostal apical cell is a very uncertain feature, is fruitless unless coördinate diagnostic characters can be found. A tegmen of *Signoretia benguetensis* is figured here (Plate 1, fig. 7) in which one of the usually constant cross veins, that at apex of the first subapical cell, is obsolete, leaving only a stump on one side. In *Pythamus* this cross vein is regularly absent. The normal forking of the main veins is of importance, but one branch of the fork may be distinct or indistinguishable in the same genus or even species, as in some of the Nirvaniidæ. Also, the method of examination has made many generic descriptions misleading. In one of the genera of this group described as having venation obsolete, when the tegmen is mounted on a slide and viewed by strong transmitted light the venation is perfectly distinct. Another,

described as with "appendix absent," shows on a mounted specimen a perfectly distinct but very narrow appendix.

If a specimen of a typical *Tettigoniella* be examined, it will be noted that the frontal suture passes on to the crown and caudad to near the position of the ocelli. Most of the crown is, therefore, merely an inflated and highly specialized "front," in the morphological application of the term. In fact, in *Tettigoniella,* we commonly find the oblique stripes, so characteristic of the front in many jassoid insects, carried far over on to the crown. The actual vertex in true tettigoniellids, therefore, even in many forms with greatly produced heads, is very short, but with the ocelli actually near its fore border, the production pertaining entirely to the front, as is commonly the case in the Cercopidæ—a family that shows many close relationships with the Tettigoniellidæ sens. str. In this case the actual basal margin of the front passes across the crown often nearer its base than its apex. In some groups the morphological vertex itself is produced, carrying forward the ocelli, which may thus even come to lie on the face, but still in the same relation to the morphological "front." It thus results that the use of the word "vertex" as equivalent to "crown of head" is entirely erroneous in many cases. The word "vertex" as it occurs in descriptive literature relating to Tettigoniellidæ, Bythoscopidæ, and some other groups should be replaced by "crown."

In some groups the actual upper margin of front and the anterior margin of true vertex adjoin along the anterior margin of the dorsum of head, and in this case the use of the word "vertex," for the entire disk of the crown within the lateral sutures, is correct. In this case the sutures may be clearly marked or entirely obsolete, but the ocelli will usually be found on the anterior margin or immediately above or below it. If the sutures are clearly marked (as in nearly all of the genera in this group) they may be carinately raised, the carina bounding upper margin of front and anterior margin of vertex, often entirely distinct and separate. In the latter case the upper carina may be the stronger, causing the vertex to overhang and extend beyond the front, as in *Stenocotis, Koebelia,* etc.; or quite the reverse may be the case, as in *Euacanthus,* many of the Pythamidæ, and notably in *Balbillus,* but there is every gradation in this character. In the groups under discussion the two carinæ diverge laterally in all of their relative locations described above, the ocelli being commonly placed between them,

within this "ocellar area," which is usually part of the "temple," and commonly remote from the eyes. Rarely are the ocelli above or within the upper carina. The carinæ may be replaced by blunt folds, or one or the other may be absent, very rarely both. Genera with these characters have been indiscriminately scattered among Acocephalini, Errhomenellini, Tettigoniellini, Jassaria, Hecalusaria, Cephalelusaria, Phrynomorpharia, and even Eupterygini, without consideration of coördinate characters, with the effect of destroying the homogeneity of all these groups, and rendering their systematic definition and synopsis impractical.

True Acocephalini, however, have scarcely more than the value of a "group" in the Phrynomorphini, since, as in most true Jassidæ sens. str., the basal lateral carinæ or sutures of front pass over the anterior margin of crown to near the position of the ocelli. It is also doubtful if the Errhomenellini, including *Errhomenellus, Anosterostemma, Chiasmus, Uzelina,* and *Tylozygus,* should be associated closely with the Tettigoniellini. The Penthimiidæ form an assemblage coördinate with Thaumastoscopidæ and Gyponidæ, very homogeneous in form and many important structural characters. Distant's "Mukaria" is separated far from the Tettigoniellidæ and placed among the true jassids, solely because the ocelli are indistinguishable; but two members of the group as he constitutes it are otherwise typical Penthimiidæ and the third is apparently unrelated. Most jassoid groups contain some members with ocelli small, weak, or indistinguishable.

If some of these most disturbing and elsewhere unrelated elements, injected into otherwise homogeneous assemblages and reviewed in the present paper, are brought together and their anatomical details compared, their close genetic relationship will be at once recognized, their interrelationships being closer than with other jassoid insects. It is impossible to present more than a temporary arrangement of these in their relations with older families. The groups here termed families and subfamilies may not be of equivalent grades, but the segregation of them is certainly justified, and still further division of the old family Jassidæ is much to be desired in order to make possible the classification of thousands of tropical forms. It is believed that in the future system of the jassoid insects many families will have to be recognized, and that some of the present subfamilies will then appear as well-founded families. In the meantime rapid additions to material in these little-known groups

is greatly increasing our knowledge of them and making clear their affinities.

Any arrangement based upon the position of the ocelli, used as quite apart from the structural modifications and accompanying sculptural features of the cephalic sclerites that bring about the apparently different positions of the ocelli, can only lead to utter confusion when an attempt is made to arrange the vast tropical faunæ by this ancient and impossible "system." If, instead, we use the fundamental structure of the head, we quickly associate what are evidently closely related forms that were formerly scattered through various sections of the old system. Out of the remarkably homogeneous series of species in the Nirvaniidæ, with a remarkable similarity in fundamental anatomy and likeness in bodily form and even in color patterns, some would be placed in Phrynomorpharia, some in Acocephalini, and some in Tettigoniellidæ—and this has actually occurred.

The following tentative synopsis will bring out some of the relationships discussed above. It does not presume to be the presentation of a complete system for the Jassoidea. Some of the most important anatomical features of very many jassoid genera are undescribed and omitted from figures, so that a general system could not be developed without visits to many of the European collections. The new families proposed are even more distinct than Ulopidæ and Paropiidæ, which have been long recognized as good primary groups. The "Jassidæ" of this synopsis will have to be further divided. Some of the divisions long recognized, like the Eupterygini, have never been diagnostically characterized. The accepted characterization of Eupterygini will certainly as readily admit to it many tropical forms of other groups like *Nirvana* that have no relation to true Eupterygini.

In future studies and especially in reëxamination of previous types a careful comparative study of leg structure seems certain to yield results of great value. The great diversity of structure in the hind tarsi is shown in the accompanying figure (Plate 1, fig. 1). In *Onukia* (Plate 1, fig. 1, *a*) and *Pythamus* (Plate 1, fig. 1, *b*), of the Pythamidæ, the third joint is inserted in second, and second in first, far before the apex, and the length of the first joint is as great as, or greater than, the following two together, the first and second joints being crowned with groups of stout spines or teeth. In both cases there are no lateral spines on the first joint except at the insertion of the succeeding joint. In *Stenometopius* (Nirvaniidæ-Stenometopii-

næ) (Plate 1, fig. 1, *c*) and *Stenotortor* (Nirvaniidæ-Macroceratogoniinæ) (Plate 1, fig. 1, *e*), the first joint is distinctly shorter than the two succeeding, the terminal crowns of spines being reduced, and the first joint is supplied with numerous lateral spines. In these cases the third and second joints are inserted but little before the apex of the proximal joints, or at the extreme apex as in *Stenometopius*. In *Paropia* (Paropiidæ) the apical crowns of spines are entirely lacking and the second joint is distinctly shorter than the third, as in *Preta* (Signoretiidæ) (Plate 1, fig. 1, *d*). However, it will be impossible to make generalizations as to these characters until the types of all older species in these groups can be reëxamined.

Superfamily JASSOIDEA

Synopsis of families.[9]

a^1. Upper part of front strongly raised and produced, its posterior portion forming a large part of superior surface of head (crown); the true vertex confined to basal portion of crown, the ocelli thus on posterior disk of crown and usually remote from eyes.

b^1. Lateral sutures of front distinctly continued over the obtuse anterior margin of crown to near the position of ocelli (as in the Cercopidæ); antennæ between and near eyes .... **Tettigoniellidæ.**

b^2. Lateral sutures of front obsolete beyond antennæ or beyond anterior border of crown.

c^1. Antennæ not far removed from eyes and near but never above level of eyes; lateral margins of front obsolete beyond scrobes.

d^1. Head acute angled between crown and face; face of normal proportions; lateral sutures of front entering and terminating in antennal scrobes, face shallowly concave; body long ovate. **Gyponidæ.**

d^2. Head obtusely rounded between the strongly declivous crown and face, strongly overhanging the latter, which is deeply concave; lateral sutures of front passing mesad of antennæ; face very short, far broader than long .... **Penthimiidæ.**

c^2. Antennæ situated entirely above and far removed from eyes; head anteriorly transversely thin laminate.

d^1. Outlined lower portion of front short and broad. **Thaumastoscopidæ.**

d^2. Outlined lower portion of front long and narrow .... **Ledridæ.**

a^2. Upper part of front confined entirely to face, except sometimes for a narrow border.

b^1. Vertex entirely superior, occupying nearly all or all of crown, the junction with front occurring on anterior border of crown, the ocelli on or near anterior border of head.

[9] This synopsis, in the present abbreviated from, uses principally cephalic characters. Many coördinated characters can be drawn from other parts of the body, notably tegmina, wings, and legs.

c^1. Basal suture of front distinct and entire, centrally at least, approaching more or less closely the anterior margin of vertex; when subobsolete above, its position always marked by a fold or carina; in the latter case, the remaining portion of frontal suture is always directed toward the base of front and not toward ocellus; anterior border of vertex usually marked by a sharp margin or carina.

d^1. Anterior border of vertex sharply laminately expanded, distinctly overhanging upper part of front; antennæ situated far mesad of eyes; ocelli, when distinguishable, lying between extended margin of vertex and basal margin of front in a transversely triangular (rarely linear) ocellar area and very remote from eyes.

e^1. Pronotum extended between and cephalad of eyes; vertex very short, transverse, and deeply concave.

f^1. Tegmina normally veined; genæ narrower than front; front strongly excavate, with high raised margins; clypeus little exserted; ocellar area very broad; hind tibiæ with very few small spines and hairs on apical half; sculpture characterized by a deep thimble pitting........................ **Paropiidæ.**

f^2. Tegmina with numerous supernumerary veins; genæ wider than front; front convex; clypeus long exserted; ocellar area narrow, bounded beneath by a shallow fold; hind tibiæ with stout spinose teeth, few in number but distributed along entire length; sculpture characterized by coarse striations and wrinkles............................ **Stenocotidæ.**

e^2. Pronotum not abnormally extended between eyes; vertex not very short and long transverse, the width not more than twice length; ocelli a little nearer to eyes than to median line or indistinguishable.

f^1. Genæ longer than broad, flat or concave, outwardly emarginate, normally bordering the loræ to the clypeus; scrobes very shallow and lacking strong supra-antennal ledges (as in Stenocotidæ); pronotum with very short lateral margins, converging anteriorly, ocelli distinct.................... **Koebeliidæ.**

f^2. Genæ broader than long, strongly convex, not passing loræ (at level of face), their apical margins roundly curved inward to meet the front above the loræ, leaving outer margin of latter fully exposed in facial view; scrobes very deep, under strongly overhanging and curved supra-antennal ledges; pronotum with very long lateral margins, usually converging posteriorly.................................. **Ulopidæ.**

d^2. Anterior border of vertex sharply marked (head may be laminately extended between eyes) but never with this margin extended beyond and overhanging upper part of front; usually with clearly marked subtriangular ocellar areas at the sides between vertex and front; these areas are commonly occupied by the ocelli, though the latter may occur near by on upper surface of crown, then usually on or outside the carinate or raised lateral margin of vertex; antennæ situated close to interior line of eyes.

*e*¹. Upper margin of front a little extended beyond margin of vertex and plainly visible in dorsal view at least at sides, the lateral and anterior submarginal carinæ of vertex usually distinct, often very strong.

*f*¹. Pronotum very long, strongly produced and outcurved caudad, largely covering the scutellum; head with eyes broader than pronotum; vertex with a very strong thickened basal transverse ridge; supra-antennal ledge callously thickened and lobed over frontal margin; clypeus truncate or notched apically and little or not exserted; sides of front not sinuate at scrobes; ocelli in marginal areas and visible from above or below .... **Signoretiidæ.**

*f*². Pronotum not produced caudad over the very large scutellum, the hind border truncate or concave; head more or less distinctly narrower than pronotum; vertex without strongly thickened basal ridge; supra-antennal ledge neither strongly callose nor lobed over frontal margin; antennæ between the eyes near middle of their inner margins.

*g*¹. Pronotum short, broad, broadly rounded anteriorly, the head but slightly narrower; vertex very broad, nearly twice as broad as long; width of head greater than length of head and pronotum together; ocelli situated a little within anterior margin of crown, but outside the anterolateral carina of vertex, and invisible in facial view. **Euacanthidæ.**

*g*². Pronotum more or less narrowly rounded anteriorly, the head very distinctly narrower, vertex always much less than twice as broad as long; width of head always much less than length of head and pronotum together; ocelli in or very near lateral areas, and usually visible both in dorsal and facial views .... **Pythamidæ.**

*e*². Upper margin of face not at all extended beyond margin of vertex and not visible in dorsal view, or only little so just in front of eyes; ocelli on anterolateral border of head or just above or below it; loræ very small and narrow; tegmina usually without anteapical cells and venation usually indistinct basally; antennæ usually inserted distinctly above the eyes in facial view, rarely on upper line of or between eyes, in which case the head is long-produced .... **Nirvaniidæ.**

*d*². Basal suture of front usually obsolete, the basal lateral sutures running to and terminating at or near the ocelli; vertex usually clearly connate with the front, only in highly specialized groups with a sharp edge or with transverse carinæ on anterior border; ocelli on anterior border of head or above it .... **Jassidæ.**

*b*². Vertex more or less roundly curved on to face, and broadly visible in facial view, the ocelli facial and between the eyes or above them; basal suture of front, when present, far anterior to base of face; that portion of vertex visible from above usually very short and broad .... **Bythoscopidæ.**

PAROPIIDÆ

(*Megophthalmidæ*)

One has only to study *Paropia* and *Stenocotis* or *Kyphocotis* (Plate 1, fig. 2) side by side to realize their close relationship in essential structure. From my previous account of this subfamily was omitted the genus *Mesoparopia* Matsumura,[10] described as of this family, with two species, *M. nitobei* from Formosa and *M. fruhstorferi* from Tonkin.

ULOPIDÆ

A reëxamination of material in this family makes clear a close relationship with *Paropia* and *Stenocotis.* The apparent absence of ocelli is a character of little value. In related genera ocelli may be very small and weak, and, in the confusion of coarse pits over the ocellar area, rudiments of ocelli might easily exist but be indistinguishable. It should not be stated that they are "absent" until microscopical sections are made of the ocellar area. The relationship of *Ulopa* and *Paropia* is evident from the accompanying figure (Plate 1, fig. 3, *b–e*) which shows frontal and lateral views of the side of the face in both of these genera.

The examination of material of the genus *Moonia* Distant has been made possible through the kindness of the director of the Zoölogical Survey of India. This shows at once, what had been suspected, that this genus is one of the Ulopidæ and very closely related to *Ulopa,* from which it differs most conspicuously in the shorter vertex—a minor character. The structure of its face shows that *Mesargus* Melichar[11] should be placed in this family. Distant[12] notes its similarity to *Moonia. Radhades, Sitades,* and *Durgades* of Distant show some superficial resemblance to *Moonia,* but apparently belong near *Nehela. Ulopa* and *Moonia* possess a character that is unique among jassoid insects; namely, strongly rounded genæ, the sharp outer edge of which curves mesad to the front above the loræ, the lower margin passing beneath the loræ, leaving the latter with the outer border apparently free, in facial view. These two genera correspond in various other essentials. *Daimachus* Distant, placed in the Ledridæ, is *Ulopa. Gubela,* also placed in the Ledridæ, is very close to *Ulopa. Sichaea* Stål appears to be related to *Ulopa.*

[10] Annot. Zool. Japon. 8 (1912) 27.
[11] Homop. Ceylon (1903) 176.
[12] Fauna Brit. India, Rhynch. 4 (1908) 313.

KOEBELIIDÆ

The genus *Koebelia* with the species *californica,* was described by me twenty-five years ago for a very peculiar and isolated western American type, for which I suggested the family name Koebeliidæ.[13] At that time I possessed specimens of both *Ulopa* and *Paropia,* but did not realize their relationship, since the facial characters seemed to be very distinct from either. Not until material of *Stenocotis* came to hand did the relationship appear clear, the genus lying between *Stenocotis* and *Ulopa,* though very distinct from either (Plate 1, fig. 3, *a*). VanDuzee lists the genus under the "Paropiinæ," synonymizing Koebeliidæ with this subfamily. This is an entirely erroneous disposition of it, since it is far more closely related to Ulopidæ than to Paropiidæ. Moreover, the characters which separate it are entirely equivalent in value to those of the other families of this series. The strong dissimilarity between it and either *Ulopa* or *Paropia* is evident in important facial characters (Plate 1, fig. 3, *a*). However, its intermediate position between *Ulopa* and *Paropia* on the one hand and the Stenocotidæ sens. str. on the other is also indicated by comparison of the figures of *Koebelia* and *Kyphocotis tessellata* Kirkaldy (Plate 1, fig. 2, b).

SIGNORETIIDÆ

In my first paper on this group it was quite by chance that the two species of *Signoretia* treated represented two natural divisions of the genus, one with a short swollen declivous head, the other with a longer, less-swollen head, held in the long axis of the body. The collection of abundant material of true *S. malaya* Stål, at Singapore, enables me to identify certainly *S. malaya* of my former paper as merely a geographical form of it. In his descriptions Distant gives no specific structural characters for the two apparently very distinct species *S. aureola* Distant and *S. greeni* Distant, so that it is impossible to judge of their relationships. Characteristic of this family are the very small and short loræ.

Synopsis of genera.

a^1. Basal cell of clavus small and without cross veins; pronotum with two rudimentary submedian carinæ crossing the anterior transverse furrow or with a more or less complete median carina......... **Signoretia Stål.**

a^2. Basal cell of clavus large and with two cross veins (additional cross veins may occur); pronotum with two complete submedian carinæ. **Preta Distant.**

[13] Psyche 8 (1897) 76.

Genus **SIGNORETIA** Stål

Synopsis of species.

*a*¹. Plane of vertex subhorizontal, not declivous, and not in line (profile) with anterior curve of pronotum; front gently convex; pronotal median carina entirely absent; distinct, short, submedian longitudinal ridges crossing the anterior transverse depression; margin of basal cell of clavus about three times as long on the commissure as on the anal margin.

*b*¹. Pronotal submedian longitudinal ridges crossing anterior depression strong, sharply raised; intersections between thimble pits of pronotum sharp and strong; without black spots; length of female, 6 to 7 millimeters .... **S. malaya** Stål.

*b*². Pronotal submedian ridges low, broad, scarcely distinguishable; intersections between thimble pits of pronotum low, broad, and smooth; with black spots on head and pronotum; length of female, 9 millimeters .... **S. maculata** sp. nov.

*a*². Plane of vertex strongly declivous in line (profile) with anterior curve of pronotum; front strongly swollen on apical two-thirds; pronotal median carina present, at least anteriorly, the submedian longitudinal ridges lacking; margin of basal cell of clavus little longer on commissure than on anal margin.

*b*¹. Pronotum longer than wide; ocellus distant from eye its own diameter or little more.

*c*¹. Pronotal median carina broad, callose, complete; pale colored throughout; median carina of vertex confined to base or wanting.

*d*¹. Pronotal carina strongly raised anteriorly; the subapical cell subequal in length to the small triangular outer apical cell: head with dark spots; disk of vertex with a median carina basally .... **S. carinata** sp. nov.

*d*². Pronotal carina not strongly raised anteriorly; the subapical cell much longer than the small triangular outer apical cell; head without dark spots; disk of vertex without a median carina.
S. tagalica Baker.

*c*². Pronotal carina confined to anterior half, high and strong where it crosses the anterior depression; abdomen largely black and with dark markings elsewhere; median carina of vertex complete.
S. bilineata sp. nov.

*b*². Pronotal length less than the width; ocellus distant from eye about twice its own diameter; pronotal median carina confined to anterior half; body strongly marked with black, the males much darker .... **S. benguetensis** sp. nov.

Signoretia malaya Stål.

Study of a large series of specimens of this species obtained at Singapore and Penang, show that the Philippine specimens reported as this species were correctly determined.[14] However,

[14] Philip. Journ. Sci. § D **10** (1915) 194.

since the Philippine form averages larger than the typical form, it may be distinguished by the varietal name *philippinensis*. While a very common insect at both Singapore and Penang, it has been very infrequently encountered in the Philippines; but the latter statement means little, due to our scant knowledge of the Philippine field.

Signoretia maculata sp. nov. Plate 1, fig. 4.

Pale ochraceous (probably more or less virescent in life); a large oblique spot in each lateral area of vertex, a small median quadrangular spot near anterior margin of pronotum, a small elongate median spot near posterior margin; entire costal margin (more strongly basally), claval suture, and commissural margin piceous. Tegmina subhyaline, the veins concolorous. Median vein broadly infuscated, the other veins basally, concolorous with surface. Length of female, 19 millimeters.

Length of face (Plate 1, fig. 4, *c*) a little greater than width across eyes. Front and clypeus ridged as in *S. malaya*, but the swollen median elevation of the clypeus (Plate 1, fig. 4, *b*) is somewhat nearer the base than in that species. The upper bordering carina of the ocellar area is not continuous across the anterior margin of crown as in *S. malaya*, but runs out on the smooth surface of the crown before reaching median line. Ocellus distant the length of its own diameter from the eye. Length of vertex less than half its width between the eyes. Disk of vertex not so strongly depressed as in *S. malaya*, the surface minutely sparsely roughened but not tuberculate, the median carina low, broad, and indistinct; each lateral area with a delicate curved median carina which anteriorly joins the inner end of the supraocellar carina. Pronotum (Plate 1, fig. 4, *a*) about four times length of vertex; the anterior lateral margin a little more than three times into the width; marginal carina and pleura (lateral view) as in *S. malaya*. The thimble pitting of pronotum is coarser than in *S. malaya*, the intersections between pits being broader, lower, and smoother, particularly near anterior border. The two short submedian longitudinal ridges crossing the anterior depression in *S. malaya* are here obsolete.

INDIA, Darjeeling district, Mangpu, Sureil, elevation, 1,500 meters (*S. W. Kemp*). Described from one specimen kindly loaned to me by the director of the Zoölogical Survey of India. This species may possibly find a close relative in *S. greeni* Dis-

tant, when the structural characters of that species become known.

Signoretia carinata sp. nov. Plate 1, fig. 5.

Pale ochraceous throughout, the vertex and pronotum with a whitish waxy bloom. Tegmina opaque, albescent; veins of corium concolorous; costal margin apically and apical margin slightly infuscated. Length of female, 7 millimeters.

Length of face (Plate 1, fig. 5, *c*) less than the width across eyes. Face of the *S. tagalica* type, the median frontal ridge passing but shortly and indistinctly on to clypeus, the anterolateral depressions of clypeus large, deep, and leaving but a narrow ridge between them anteriorly. The supraocellar carina is weak and coalesces with the lateral extremity of subocellar carina about halfway between eye and median line; subocellar carina sharp, strong, and continuous along the crown. Ocellus distant the length of its own diameter from eye. Length of vertex less than half width between eyes; concavity of vertex deep, rugosely roughened, and with a distinct longitudinal median carina on basal half. Pronotum (Plate 1, fig. 5, *a*) about three and a half times length of vertex; the anterior lateral margins about four and a half times into the width; marginal carina (lateral view) and pleura similar to those of *S. malaya;* thimble pitting very similar to that of *S. malaya;* with a complete median carina which is stronger anteriorly where it crosses the transverse depression. That portion of pronotum anterior to transverse depression in this species, as in *S. tagalica,* is longer and flatter than in *S. malaya,* and the transverse depression is not so broad laterally. Margin of basal cell of clavus little longer on the commissure than on the anal margin.

MINDANAO, Agusan Province, Butuan (*Baker*). The southern representative of *S. tagalica,* but quite distinct. It will now be of no little interest to examine material belonging to this section of the genus from the intervening islands.

Signoretia bilineata sp. nov. Plate 1, fig. 6.

Pale ochraceous, the pronotum whitish; lateral ridges of front and discal concavities of vertex brownish; a narrow brownish stripe, interrupted by the transverse depression, flanking median carina on either side, on anterior half of pronotum. Tegmina sordid albescent, the apical veins and the apical submargin fuscescent. Length of female, 6.4 millimeters.

Length of face (Plate 1, fig. 6, *c*) less than the width across eyes. Face of the *S. tagalica* type, the strong median ridge running out at clypeal suture; basal border of front concave in facial view. Supraocellar carina weak but traceable across anterior portion of crown near and parallel to subocellar carina which sharply borders anterior margin of crown, the latter carina depressed to the level of the discal concavities of vertex; ocellus distant the length of its own diameter from eye. Length of vertex less than half width between eyes; concavities of vertex shallow, with a strong complete median white carina. Front in lateral view (Plate 1, fig. 6, *b*) strongly and rather abruptly swollen on lower half. Pronotum (Plate 1, fig. 6, *a*) about three and a half times length of vertex, the anterior lateral margins into the width a little more than three times; marginal carina (lateral view) and pleura similar to those of *S. malaya.* Intersections between thimble pittings of pronotum narrower than in *S. maculata* but also low and smooth; median carina distinct only on anterior half, very strong where it crosses the anterior depression. Margin of basal cell of clavus about a half again longer on the commissure than on the anal margin.

BORNEO, Sandakan (*Baker*).

Signoretia benguetensis sp. nov. Plate 1, fig. 7.

Female pale ochraceous; dorsum of abdomen, except segmental margins, black; median carina of front and lateral ridges brownish; two small spots at apex of vertex and two large spots at base black; a median longitudinal piceous band on pronotum, extending from transverse depression to base of pronotum, broader posteriorly. Tegmina translucent, the veins of corium and clavus slightly infuscated. Length, 6.5 millimeters.

Male with dark markings more deeply colored and more extensive. Frontal carina black, all bordering carinæ of vertex broadly deep black; pronotum largely washed with blackish. Tegmina palely infuscated throughout, the veins darker, claval veins blackish. Length, 6 millimeters.

Length of face (Plate 1, fig. 7, *c*) less than width across eyes. Face similar to that of *S. bilineata,* but the front in lateral view (Plate 1, fig. 7, *b*), though swollen, is evenly curved from base to apex and not strongly suddenly protuberant below; anterolateral depressions of clypeus narrow, the latter with a dark spot at middle; lateral ridges of front very strong. The supraocellar carina is weak anteriorly and joins subocellar carina

nearer to median line than to ocellus, the subocellar carina sharply bordering anterior margin of crown, which is subtruncate; basal carina of vertex very thin and sharp; concavities of vertex deep, the anterior margin strongly raised, the median carina subobsolete, the surfaces minutely roughened and subdivided by low indistinct intermediate ridges, which parallel the lateral and basal carinæ; ocellus distant from eye about twice its diameter. Length of vertex less than half width between eyes, but greater than lateral margin of pronotum, as in *S. carinata*. Pronotum (Plate 1, fig. 7, *a*) three times length of vertex, the anterolateral margin about five times into the width; marginal carina (in lateral view) straight, the pleura with an irregular fold near posterior margin and a vertical median series of large elongate pits; thimble pits of pronotum very large, somewhat irregular, the intersections narrow but low and smooth; transverse depression nearer to foremargin than in other species, the median carina on anterior half of pronotum sharp and strong but depressed where it passes the transverse depression. Margin of basal cell of clavus somewhat longer on the commissure than on the anal margin.

LUZON, Benguet Province, Pauai (Haight's Place), altitude, 2,400 meters (*Baker*). This species presents the only case in the family known to me of strongly marked sexual dimorphism. It may possess relationships with *S. sumatrana* Schmidt, which may exhibit a similar dimorphism, but this cannot be known until the structural characters of *S. sumatrana* are described.

Genus **PRETA** Distant

Synopsis of species.

a^1. Head and thorax long; thimble pitting of pronotum weak but distinct; tegminal appendix well formed and reaching apex; subapical cell about as long as width of succeeding apical cell. **P. gratiosa** Melichar.

a^2. Head and thorax short; thimble pitting of pronotum obsolete, the surface smooth; tegminal appendix reduced, reaching about halfway from apex of clavus to apex of tegmina; subapical cell much longer than width of succeeding apical cell.................. **P. luzonensis** sp. nov.

Preta gratiosa Melichar. Plate 1, fig. 8.

Melichar, Homop. Ceylon (1903) 160 (*Signoretia*).

Pale ochraceous (virescent in life); fore and middle tibiæ, apically, and tarsi darker. Corium and membrane subhyaline, the apical veins a little infuscated, clavus opaque, whitish.

Vertex and pronotum commonly covered with a white waxy bloom. Length, female, 7 millimeters; male, 6.5.

Length of face (Plate 1, fig. 8, *c*) nearly a third greater than width across eyes. Face as in *Signoretia malaya* but clypeus narrower, its basal suture more strongly curved and facial ridges extended to apex. The supraocellar carina continuous over the crown of the head some distance from and subparallel to subocellar carina, the latter bordering crown in front as a sharp porrect margin. The two concavities of vertex slope gradually caudad, deeper at inner basal angles next the median carina, which is strong and complete. Ocellus distant from eyes about its own diameter. Length of vertex a little more than three-fourths width between eyes and half again longer than anterolateral margin of pronotum. Pronotum (Plate 1, fig. 8, *a*) about twice length of vertex; the anterolateral margin into width a little more than two and a half times; marginal carina and pleura as in *Signoretia malaya;* thimble pitting large but shallow and inconspicuous; two submedian carinæ corresponding to the two rudiments found in *Signoretia malaya* pass from fore to hind margin, diverging somewhat caudad, and are high, sharp, and strong throughout. Venation of corium and membrane as in *Signoretia malaya,* but pitting along veins very inconspicuous and apically entirely lacking; conspicuous pitting occurs only at base of subcostal area and along claval vein at base; basal cell of clavus very large and with two oblique cross veins.

STRAITS SETTLEMENTS, Singapore and Penang (*Baker*). This species was found to be abundant in both of these regions, and a slightly different geographical form of it is common at Sandakan, Borneo. A similar form is to be expected in Tawitawi and elsewhere in the Philippines since the genus ranges to northern Luzon. This species is referred to *P. gratiosa* Melichar, described from Ceylon, and recorded by Distant[15] from Tenasserim, but with some doubt, since the figures of Distant and Melichar differ widely in details, though the present form is likely to prove the same, at least, as that from Tenasserim.

Preta luzonensis sp. nov. Plate 1, fig. 9.

Pale ochraceous (more or less virescent in life); median keel and lateral ridges of face slightly darkened; tegmina trans-

[15] Fauna Brit. India, Rhynch. 4 (1908) 234.

lucent, the veins pale ochraceous. Length, female, 7 millimeters; male, 6.5.

Length of face (Plate 1, fig. 9, *c*) subequal to its width. Face very similar to that of *Signoretia malaya* even in proportions; facial keel extending to middle of clypeus, though not so strong on clypeus as on front; the whole anterior portion of clypeus strongly but not equally depressed; front very slightly convex in profile (Plate 1, fig. 9, *b*). Ocellar carinæ and carinæ of vertex as in *P. gratiosa.* Ocellus a little farther from eye than its own diameter. Length of vertex less than half width between eyes, and subequal to anterolateral margin of pronotum. Pronotum (Plate 1, fig. 9, *a*) a little more than three times length of vertex; the anterolateral margin into width a little more than three times; thimble pitting entirely obsolete except for faint indications along lateral borders; submedian carinæ similar to those of *P. gratiosa,* as is also the venation.

LUZON, Benguet Province, Baguio (*Baker*). Not uncommon. This very distinct species has the cephalic and thoracic proportions of *Signoretia malaya,* but the pronotal carinæ and claval venation of *Preta gratiosa.* It differs from all other members of the family in lacking the thimble pitting on pronotum.

EUACANTHIDÆ

The accompanying figure (Plate 1, fig. 10) will make it clear that in *Euacanthus* we are dealing with a type that not only is closely related to *Signoretia* and *Pythamus* in several fundamental respects, but that also shows no affinity to the Tettigoniellidæ where it is usually placed. It is, in its way, as isolated a type as either *Ulopa* or *Paropia.* The position of the ocellus with the peculiar accompanying structures is similar to that of the Signoretiidæ and Pythamidæ, as is the tegminal venation.

Bundera Distant [16] apparently belongs here, but the ocelli are not mentioned in the generic description.

PYTHAMIDÆ

There can be no doubt of the interrelationship of *Onukia* and *Pythamus* on the one hand, and *Onukia* with *Tortor* and *Dryadomorpha* on the other. The structure of the pronotum, as in the case of *Muirella,* suggests certain Jassaria, but the cephalic characters are of greater importance and are unmistakable. Dis-

[16] Fauna Brit. India, Rhynch. 4 (1908) 228.

covery of species of *Pythamus* with the laminate cephalic carina very weak makes this relationship clearer. Both *Apphia* and *Omaranus* of Distant belong to this family, as noted under *Onukia*. The collection of more material of *Tortor* and *Dryadomorpha* in Queensland is greatly to be desired.

In all genera of this family the pronotum is truncate or slightly incurved posteriorly; the anterolateral carinæ of vertex reach apex or nearly so; the sides of front are very shallowly sinuate opposite antennal scrobes; the clypeus is strongly narrowed apically.

Synopsis of genera.

a^1. Tegmina of normal texture, the venation distinct throughout (except in *Oniella*); ocelli large.
- b^1. Sides of pronotum strongly converging cephalad; head much narrower than pronotum.
  - c^1. Median carina of vertex, in part at least, laminately raised, the disk of vertex strongly concave on either side of the lamina, the basal margin strongly and sharply raised; pronotal median carina present or wanting.................................. **Pythamus** Melichar.
  - c^2. Median carina of vertex not laminately raised, sometimes weak or obsolete apically; surface of vertex slightly concave, plane or slightly convex; basal margin not strongly raised; pronotum without median carina.
    - d^1. Posterolateral carina of vertex distinct throughout, the ocelli pushed forward into facial view as in other genera; median carina of vertex distinct; clypeus narrowly rounded apically; tegmina with venation distinct throughout.. **Onukia** Matsumura.
    - d^2. Posterolateral carina of vertex obsolete, and anterolateral portion weak, the ocelli thus resting on plane of crown and not visible in facial view; median carina of vertex obsolete; clypeus subtruncate apically; tegmina with venation obscure basally. **Oniella** Matsumura.
- b^2. Sides of pronotum straight in long axis of body, the head little narrower .... **Chudania** Distant.[17]

a^2. Tegmina coriaceous, venation at least partly obscure and indistinguishable; ocelli small and weak or indistinguishable.
- b^1. Head in profile not thin, similar to *Onukia;* clypeus widened apically; loræ wider than anterior part of clypeus; front not concave; pronotal lateral carinæ evanescent................................ **Dryadomorpha** Kirkaldy.[18]
- b^2. Head in profile thin; front concave; loræ minute...... **Tortor** Kirkaldy.[18]

Genus **PYTHAMUS** Melichar

Synopsis of species.

a^1. Vertex strongly produced, distinctly longer than pronotum; front somewhat concave in profile; pronotum in part very finely transversely

[17] The position of this genus is uncertain.

[18] *Tortor* and *Dryadomorpha* are referred here provisionally.

aciculate and sparsely punctate and without trace of median carina; scutellum shagreened, clavus punctate only along veins; front shagreened........ **P. productus** sp. nov.

a^2. Vertex subequal in length to pronotum; front always convex in profile.

b^1. Pronotum short, width twice the length; scutellum distinctly shorter than vertex; pronotum coarsely transversely wrinkled and without trace of median carina; scutellum rugose at base; clavus punctate only along veins; front rugose........ **P. decoratus** sp. nov.

b^2. Pronotum long, width much less than twice length; scutellum subequal to vertex in length; pronotum closely, deeply, grossly thimble pitted, as are also scutellum and clavus; pronotum with a distinct median carina on anterior two-thirds or at least a trace of one; face shagreened........ **P. melichari** Baker.

c^1. Whitish costal border of tegmina with two large inwardly projecting albescent lobes or spots; vertex longer than width across anterior margins of eyes........ **P. melichari** Baker var. **bilobatus** var. nov.

c^2. Whitish costal border of tegmina without inwardly projecting lobes; length of vertex subequal to width across anterior margin of eyes.

d^1. Pale costal border of tegmina expanded into radial cell; entire apical area of scutellum and two dots anterior to it yellow; black of dorsum without strong bluish reflections; size small.

e^1. Loræ not black.

f^1. Lateral spots of vertex broadly connected with the large median triangular basal spot........ **P. melichari** Baker.

f^2. Lateral spots of vertex not connected with the very small median basal spot.

P. melichari Baker var. **singaporensis** var. nov.

e^2. Loræ black........ **P. melichari** Baker var. **mindanaensis** Baker.

d^2. Pale costal border of tegmina not expanded into radial. cell; only extreme apex of scutellum yellow; black of dorsum with a strong bluish reflection; size large.

P. melichari Baker var. **borneensis** var. nov.

Pythamus productus sp. nov. Plate 2, fig. 11.

Pale ochraceous; lateral margins of genæ, margins of front, frontal carina, two submedian stripes on front, and lateral stripes on clypeus pale brown. A supra-antennal dot and a smaller marginal dot above it black. Vertex with an irregular transverse black band on anterior half. Pronotum shaded with brownish, especially anteriorly. Scutellum with large triangular basal spots halfway between lateral angles and median line, a minute dot between each of these and median line and a fine median line reaching to transverse furrow brownish, the larger spots darker. Tegmina sordid whitish translucent, the veins broadly brownish; a larger smoky spot at middle of subcostal area, and two smaller ones on apical third, with two irregular subapical concentric stripes of the same color. Abdomen clouded with brownish. Apices of hind tibiæ and tarsi brownish. Length of female, 8 millimeters.

Length of face (Plate 2, fig. 11, *c*) a little more than one and a half times the width across eyes. Loræ smooth; genæ obscurely and transversely rugose near lateral margins; front shagreened; lateral surfaces of raised basal portion of frontal ridge rugose. Supraocellar carina sharply bordering anterior margin of vertex, subocellar carina weak and irregular but distinct from near ocellus to apex of front; area between these carinæ and to the supra-antennal carina irregularly transversely wrinkled. The ocellus lies below and touches the superior carina and is distant from eye about three times its diameter. While the outlines of front are distinct in facial view, the lateral suture actually becomes obsolete just above the supra-antennal carina. Laminate carina of vertex highest on anterior half, the lateral concavities in deeper anterior portion subobsoletely concentrically wrinkled at sides, smooth in shallow posterior portion. Length of vertex nearly a third greater than width between eyes. Pronotum (Plate 2, fig. 11, *a*) slightly shorter than vertex, the anterolateral margin into width three and a half times, the hind margin subtruncate; a broad median basal area reaching forward to three-fourths of length, minutely thickly transversely aciculate; remainder of surface on posterior half with sparse subobsolete punctures, on anterior half smooth, without trace of median carina. Scutellum wider than long and about three-fourths length of pronotum, otherwise as in *P. melichari*. Veins in tegmina weakly and subobsoletely pit margined, the surface of clavus smooth. Several supernumerary cross veins occur in both clavus and corium, one of these forming an inner subapical cell. The subgenital plate of female is deeply broadly emarginate, beyond apex of emargination and at sides strongly callosely swollen.

STRAITS SETTLEMENTS, Penang Island (*Baker*). The largest and most conspicuous species of the genus.

Pythamus decoratus sp. nov. Plate 2, fig. 12.

Face, sternites, most of vertex, anterior margin and a connected median stripe on pronotum, basal angles of scutellum, and an irregular median stripe extending from base to transverse furrow black. Anterolateral borders of head, eight small spots arranged around margin of vertex, and submedian and apical areas of scutellum yellowish. Pronotum in large part and veins of tegmina testaceous. Legs pale ochraceous; abdomen with pale brown segmental margins. Tegmina very dark smoky, two adjoining subcostal spots albescent, the proximal smaller; ex-

treme apical margin albescent, a concentric subapical stripe subhyaline. Length of female, 6.25 millimeters.

Length of face (Plate 2, fig. 12, *c*) a little less than one and a half times width across eyes. Face including loræ, apical area of genæ, and most of clypeus thickly rugose; clypeus shagreened on median basal area; genæ beneath eyes subobsoletely sparsely transversely wrinkled. Subocellar carina curving downward toward supra-antennal carina, three strong transverse carinæ between this and ocellus, the upper one subtending the ocellus; area between ocellus and supra-antennal carina also with numerous fine transverse wrinkles. Ocellus touching the normal supraocellar carina and distant from eye more than three times its diameter. Laminate carina of vertex highest at middle, tapering equally either way. Lateral concavities of vertex deepest at middle, sloping rapidly upward to carinæ in all directions and concentrically wrinkled throughout. Length of vertex a fourth greater than width between eyes. Frontal profile (Plate 2, fig. 12, *b*) abruptly prominent above the clypeus.

Pronotum (Plate 2, fig. 12, *a*) nearly as long as vertex, the anterolateral margin into width four and a half times, the hind margin very slightly incurved, the surface to near foremargin sparsely shallowly punctured and transversely wrinkled, and without trace of median carina. Scutellum much wider than long, basal angles shagreened, median basal area rugose, apical area very minutely longitudinally wrinkled. Entire clavus and the basal two-thirds of corium punctate. With several supernumerary cross veins, one forming a median subapical cell, two other strong cross veins occurring in the medial area as in *Deltocephalus*. The subgenital plate of female is shallowly broadly angularly emarginate, a blackish spot occurring beyond the apex.

BORNEO, West Borneo, Mowong (*Muir*). A small species, but one of the most highly ornamented in the genus. The lower part of the front in this species and in *P. productus* (in lateral view) is more prominent than in other species of the genus.

Pythamus melichari Baker.

In each Malayan region in which collecting has been done, we have encountered forms very closely related to *P. melichari* described from Palawan. These are all very close to *melichari* in structure, differing only in size, in minor details of markings, and in minor structural characters. In the various regions the varieties or subspecies, as we may choose to call them, present

a remarkable uniformity. It is probable that each island and distinct geographical subregion will furnish its own peculiar form of this plastic species. One of these forms has already been described under the name *mindanaensis*.[19] Three more are presented herein. The relationship of any of these forms to *Pythamus dealbatus* Melichar will remain an open question until that species can be reëxamined.

Pythamus melichari Baker var. **bilobatus** var. nov. Plate 2, fig. 13.

Lower parts largely ochraceous, upper parts largely black. Face and clypeus slightly brownish, the lateral margins of front and basal lateral margins of clypeus blackish. Mesopleura, dorsum of abdomen except basal lateral margins, outer margins of anterior tibiæ, and ovipositor black. Vertex with a narrow irregular transverse band, broader laterally before apex, and a small oval spot next each eye, yellowish lateral margins of pronotum, apex of scutellum, and two dots just before it yellowish. Extreme base of tegmina yellowish, an albescent subcostal spot next this, a larger oval albescent spot on subcostal stripe at middle extending halfway across corium and with a narrow band extending from its inner margin to claval suture; apical margin broadly albescent; remainder of tegmina black. Length of female, 6.25 millimeters.

Length of face (Plate 2, fig. 13, *c*) one and a half times width across eyes. Front, clypeus, and loræ shagreened throughout, the genæ smooth. The subocellar carina is as strong as the supraocellar and curves downward to opposite the supra-antennal carina and twice length of latter from eye; from halfway between the extremity of the subocellar carina and the antennal scrobe a strong vertical carina passes along the line of the frontal suture, then toward the ocellus; in the triangular area between these carina and the supraocellar there are about fourteen transverse wrinkles, the alternate spaces between which are finely rugose; supra-antennal area finely transversely wrinkled. Ocellus touching the normal supraocellar carina and a little more than three times its diameter from eye. Laminate carina of vertex more strongly raised at middle and anteriorly than posteriorly. Lateral concavities of vertex deepest at middle, sloping rapidly upward to carinæ in all directions and concentrically wrinkled throughout. Length of vertex a third greater than width between eyes. Pronotum (Plate 2, fig. 13, *a*) nearly as long as vertex, the anterolateral margin into width a little

[19] Philip. Journ. Sci. § D **10** (1915) 200.

more than three times, the hind margin shallowly subangularly emarginate; with a distinct median carina on anterior two-thirds; median area and basal lateral margins of scutellum very coarsely but shallowly thimble pitted; the yellow apical area of scutellum and two lateral dots before it callose and smooth. Tegmina with clavus grossly thimble pitted basally, apically the pits become subobsolete, and largely wanting in the albescent subcostal spots; without supernumerary cross veins.

BORNEO, Sandakan (*Baker*).

Pythamus melichari Baker var. **singaporensis** var. nov. Plate 2, fig. 14.

Differs from var. *bilobatus* as follows: Mesopleura with only a small blackish mark anteriorly. Ovipositor dark only at apex. Lateral yellow spots on vertex large and reaching basal carina; transverse band before apex of different shape (Plate 2, fig. 14, *a*). Pale area of tegminal subcostal area expanded into medial area and proximad of medial area. Length of female, 6.5 millimeters.

Length of vertex a fourth greater than width between eyes. Pronotum (Plate 2, fig. 14, *a*) as long as vertex, the anterolateral margin into width three and a half times. Apical area of scutellum basally sparsely strongly punctate.

STRAITS SETTLEMENTS, Singapore and Penang (*Baker*).

Pythamus melichari Baker var. **borneensis** var. nov. Plate 2, fig. 15.

Differs from var. *bilobatus* as follows: Black of dorsum with strong bluish reflection. Transverse band before apex of vertex of different shape (Plate 2, fig. 15, *a*). Pale area near outer margin of tegmina small and narrow and confined to subcostal area. Tegmina equally dark to the albescent apical border. The usual ocellar black spot invades a large part of ocellar area; the usual antennal spot occupies entire scrobe and invades lateral margin of front; upper outer angle of genæ black. Length of female, 7 millimeters.

Length of vertex a fourth greater than width between eyes. Pronotum (Plate 2, fig. 15, *a*) as long as vertex, the anterolateral margin into width three times. Apical area of scutellum entirely rugose-punctate.

BORNEO, Sandakan (*Baker*). This brilliant form, so distinct in appearance, is yet very close to *melichari* in all essential structural characters. The figure of the tegmen (Plate 2, fig. 15, *d*) shows the simple type of venation common to *melichari* and its

varieties. Comparing this with *Signoretia* it is to be noted that the area corresponding to an outer subapical cell in that genus, is here entirely confluent with the fourth apical cell.

Genus ONUKIA Matsumura

Matsumura, Annot. Zool. Japon. 8 (1912) 44.

Type, *Onukia onukii* Matsumura.

Distant has redescribed this genus in the Tettigoniellidæ under the name of *Apphia*.[20] He does not mention the ocelli or the peculiar structures connected therewith. The genus *Omaranus*, immediately following *Apphia*, also belongs to the Pythamidæ, as the general structure and the position of the antennæ clearly indicate. Here again, neither the exact position of ocelli nor the accompanying structures are described.

Synopsis of species.

a^1. Vertex in large part strongly longitudinally obliquely wrinkled; superior frontal (subocellar) carina as strong and sharp as anterior bordering carina of vertex; vertex and pronotum black.

b^1. Supra-antennal ledge acutely pointed toward scrobe, flanked by deep grooves; tegmina translucent with smoky markings. **O. onukii** Matsumura.

b^2. Supra-antennal ledge broadly curved above scrobe and not flanked by grooves; tegmina shining opaque black except for subcostal markings............ **O. corporaali** sp. nov.

a^2. Vertex almost entirely without longitudinal oblique wrinkles; superior frontal carina weak, conspicuously less strong than anterior carina of vertex; vertex and pronotum ochraceous or reddish, the former with a black spot, the latter with a dark crossband.

b^1. Width of vertex at base much more than half of pronotum; tegmina carmine except at apex; size small............ **O. muirii** sp. nov.

b^2. Width of vertex at base less than half width of pronotum; tegmina yellow except entire subcostal area; size large.. **O. kelloggii** sp. nov.

Onukia onukii Matsumura. Plate 2, fig. 16.

Matsumura, Annot. Zool. Japon. 8 (1912) 44.

This well-marked species, the type of the genus, has a very close general resemblance to *Pythamus melichari* except in the median carina of vertex.

The front, clypeus, and loræ are coarsely shagreened, the genæ are transversely wrinkled below the eye and longitudinally wrinkled near the outer margin. The lateral portions of front

[20] Fauna Brit. India, Rhynch. 7 (1918) 4.

are rather strongly and abruptly convexly raised above the lateral sutures, the disk rather strongly convex from side to side and divided by the strong, sharp, complete median carina which does not extend on to clypeus. Supraocellar carina as in *Pythamus,* but the subocellar carina passes down and to the side, closer to it, making the ocellar area narrowly long triangular (Plate 2, fig. 16, *b*) ; the frontal suture is very strong and deeply cut above the scrobe, curves around the extremity of the subocellar carina, and extends as a delicate carina medially through the ocellar area toward apex of front, being the only carina within this area, except one above this still more delicate and immediately subtending ocellus; surface of ocellar area coarsely shagreened like the front. Supra-antennal area finely transversely wrinkled throughout, strongly depressed along eye margin, this with the effect of the deep-cut frontal suture giving it the appearance of being produced to a point at the upper border of scrobe. Ocellus in the usual position for *Pythamus,* about two and a half times its diameter from eye. Vertex a little longer than wide, narrowed to an acute apex, the upper lateral portions of face broadly visible in dorsal view (Plate 2, fig. 16, *a*) ; median carina sharp and strong, of equal height throughout, but not laminately raised, lateral areas gently concave, the surface finely longitudinally obliquely wrinkled except near carina basally. Pronotum shorter than vertex, the anterolateral margin into width four and a half times; surface strongly transversely wrinkled except near anterior border, as in *Pythamus decoratus.* Entire basal area of scutellum thickly finely punctate and coarsely shagreened, the apical area finely rugose. The scutellum, as in all species of the genus, is proportionally larger than in *Pythamus,* and as in all but one (*kelloggii*) longer than the pronotum. Entire clavus, base of corium, and borders of veins subobsoletely punctured; two well-defined cross veins in distal half of subcostal area (Plate 2, fig. 16, *d*). Hind tibiæ even more strongly long spiny than in *Pythamus.*

JAPAN (*Matsumura*).

Onukia corporaali sp. nov. Plate 2, fig. 17.

Pale ochraceous below, intense shining black above; upper half of entire face and propleuræ black. Subcostal area of tegmina pale testaceous as far as an oblique black stripe at two-thirds of length; beyond this a large triangular decolored area which extends mesad across apical portion of radial cell; the cross vein at middle of this area broadly carmine, the red ex-

tending into radial cell; tegmina otherwise shining black throughout; wings smoky. Length of female, 5 millimeters.

Differs from *O. onukii* in structure, as follows: The carinate continuation of lateral frontal suture passing through center of ocellar area and the carina immediately subtending ocellus are very strong and complete, as strong as supraocellar and subocellar carinæ; the supra-antennal area less strongly depressed next eye and next frontal suture, sloping more gradually to antennal scrobe. Vertex as long as wide between eyes; oblique longitudinal wrinkles of disk very strong and confined to anterior half, entire basal portion shining and minutely sparsely punctured. Pronotum (Plate 2, fig. 17, *a*) a little shorter than vertex, the anterolateral margins into the width four and a half times; transverse wrinkles subobsolete, the surface sparsely punctate. Median basal area of scutellum subobsoletely rugose, the apical area as in *O. onukii*. With but one oblique cross vein in distal portion of subcostal area.

SUMATRA, Baroe, Bandar (*J. B. Corporaal*). One specimen of this beautiful species, which represents the farthest southwestern range of this genus as now recognized.

Onukia muirii sp. nov. Plate 2, fig. 18.

Pale ochraceous below; vertex basally and pronotum reddish; vertex with a large irregular median black spot on anterior half; pronotum with an anterior median stripe and a connected transverse median line blackish; scutellum blackish except for two subapical spots and extreme apex. Tegmina carmine to line of apical cross veins, beyond this testaceous with red veins. Length of female, 5 millimeters.

Differs from *O. corporaali* in structure, as follows: A second distinct transverse carina in the ocellar area between the median carina and that subtending the ocellus; also a transverse carina on basal lateral area of front near the subocellar carina and parallel with it. Vertex not as long as width between eyes; surface little depressed, plane, but slightly roughened and without oblique longitudinal wrinkles except immediately adjoining lateral carina. Pronotum (Plate 2, fig. 18, *a*) as long as vertex, the anterolateral margin into width about four times; surface very sparsely punctate, and medially with indications of subobsolete transverse wrinkles. Tegmina with venation as in Plate 2, fig. 18, *d*. External genitalia very large, as long as remainder of abdomen, the subgenital plate broadly shallowly angularly emarginate.

BORNEO, West Borneo, Mowong (*F. Muir*): British North Borneo, Sandakan (*Baker*). This conspicuous species is very abundant in Borneo.

Onukia kelloggii sp. nov. Plate 2, fig. 19.

Pale ochraceous, the pronotum a little darker. Front with a black dot on either side below antennæ. Vertex with a large irregular black spot on anterior half. Pronotum medially and along hind margin blackish. Tegmina pale yellowish to apical cross veins, brighter basally, the entire subcostal and apical areas decolored and hyaline. A dark spot at base of subgenital segment. Length of female, 7 millimeters.

Differs from *O. muirii* in structure, as follows: Sides of front much more gradually curved from disk to lateral suture. Ocellus distant from eye about four times its diameter. Vertex slightly longer than width between eyes. Pronotum (Plate 2, fig. 19, *a*) slightly shorter than vertex, the anterolateral margins into width about five and a half times, hind margin nearly truncate. Scutellum shorter than pronotum.

CHINA, Fukien Province, Foochow (*C. R. Kellogg*). A large conspicuous species. More specimens, representing both sexes, are much desired. This species is apparently closely related to *Onukia* (*Apphia*) *burmanica* Distant.[21]

Genus **ONIELLA** Matsumura

Matsumura, Annot. Zool. Japon. 8 (1912) 46.

Type, *Oniella leucocephala* Matsumura (Japan).

This genus is a weak, reduced edition of *Onukia*. It is however true here, as all through these allied families, that strong superficial resemblance may be accompanied by striking generic divergence in structural characters. As indicated in the generic synopsis and the accompanying illustration (Plate 2, fig. 20), this genus is well separated from *Onukia*.

Matsumura refers here two species from China described by Melichar as *Tettigoniella excelsa* and *T. honesta*.[22] They appear to belong to this family; but since Melichar figures both of them with the head distinctly wider than the pronotum, it may be questioned if they belong in the genus *Oniella*.

In the paper above mentioned, Matsumura describes another species, *O. niisimae*, from Japan.

[21] Fauna Brit. India, Rhynch. 7 (1918) 4.
[22] Ann. Mus. Zool. St. Petersb. 7 (1902) 131, 132.

Genus DRYADOMORPHA Kirkaldy

Kirkaldy, Bull. Hawaiian Sugar Planters' Assoc. 1 (1906) 335.

Type, *Dryadomorpha pallida* Kirkaldy (Queensland).

Later Kirkaldy [23] described another species, *D. lotophagorum*, referred to this genus.

Genus TORTOR Kirkaldy

Kirkaldy, Bull. Hawaiian Sugar Planters' Assoc. 3 (1907) 42.

Type, *Tortor daulias* Kirkaldy (Queensland).

NIRVANIIDÆ

The members of this family formerly known have been variously treated. Distant places them with *Hecalus*. Kirkaldy located them first with *Spangbergiella* and afterward with the eupterygids. Lately, McAtee [24] regards *Nirvana* as one of the Eupterygidæ. All of these references are based upon superficial resemblance and are without any justification in comparative anatomy. These insects have no relationship with the eupterygids and but a superficial resemblance to *Hecalus* and *Spangbergiella*. Subapical veins in the tegmina are always evident by transmitted light, and occasionally one or more subapical cells are more or less clearly outlined. McAtee and some other authors have described the tegmen as without an appendix, but an appendix is always present, though sometimes much reduced and very narrow. The venation of wings is similar to that of typical Jassinæ.

The reference of *Stenometopius* to this family might seem unnatural if it is compared only with *Nirvana*, but the transition to this extreme type occurs through *Pythonirvana*.

The study of species in this group is complicated by the fact that there exists in most of the genera a strong sexual dimorphism in the form of the head and some other characters, not noted by previous authors. The vertex of female is commonly a little larger and with a more strongly rounded apical margin than in the male, and the color markings of the male are usually more or less reduced. There may also be a sexual difference in form of apex of tegmina. Thus it seems probable that *Kana thoracica* and *K. ramificata* of Distant are the sexes of one species, and similarly that *K. illuminata* and *K. signata* are the sexes of

[23] Bull. Hawaiian Sugar Planters' Assoc. 3 (1907) 41.

[24] Proc. Biol. Soc. Washington 31 (1918) 118.

another. Distant does not mention the sex of the specimens described and gives no diagnostic structural characters.

The position of the ocelli in this family varies, from points on the crown in front of the eyes and near the margin to points on or below the anterior margin of crown, but always accompanied by peculiar and characteristic surrounding structures—and this in forms which in all other characters show the closest relationships, thus breaking down entirely the ancient definition of jassoid families based on position of ocelli alone. Such wide difference in position of ocelli is more apparent than real, since the relation of the ocelli to certain fundamental characters of head structure in this family is very much the same in all. The former lack of understanding of the Acocephalini, Hecalusaria, and many other jassoid groups has been due to neglect to examine the position of the ocellus as related to the course of the frontal sutures and the morphological limits of the true vertex where these can be identified.

It seems quite possible that some of the genera recently described[25] as eupterygids do not belong in that group, but will find their nearest relationships with this family; for instance, *Bolanus, Bolanusoides, Camulus,* and *Augulus.* Distant does not even mention the ocelli in any of these and does not mention wing venation, which is the basis of the present classification for the Eupterygidæ. His genus *Anomiana* belongs in the Balcluthini, and *Chickkaballapura, Paivanana,* and *Empoascanara* are perhaps not eupterygids.

It seems quite probable that the genus *Mohunia* Distant[26] belongs to this family, judging from the face, form of vertex, and venation. For this genus, also, the position of ocelli is not described.

Atritona Melichar[27] is a good member of this family, but the structures surrounding the ocellus are not described; nor is the apical venation of tegmina, which would probably be distinguishable by transmitted light. The form of the head is unique. The genus was described from East Africa.

Likewise *Hodoedocus* Jacoby,[28] with *Kosasia* Distant[29] as a synonym,[30] is apparently a member of this family, judging

[25] Fauna Brit. India, Rhynch. 7 (1918).
[26] Op. cit. 4 (1908) 272.
[27] Acta Soc. Ent. Bohem. 11 (1914) 6.
[28] Sjöstedts Kilimandjaro-Meru Expedition Stockholm 12[7] (1910) 126.
[29] Fauna Transvaal. 1 (1910) 240.
[30] Fide Melichar, loc. cit.

from the figures given. The head and venational characters appear to indicate this position.

Synopsis of subfamilies.

a^1. Antennæ situated at upper angle of eyes (in facial view) or above this; lateral carinæ of vertex more or less distinct; ocelli always visible from above, on upper portion of lateral border, or on anterolateral portion of crown; eyes prominent; posterior border of pronotum more or less distinctly incurved.

b^1. Antennæ seated in deep transverse sharp-margined scrobes; face about as broad as long or broader; eyes small; vertex short half-ovate. **Macroceratogoniinæ.**

b^2. Antennæ in shallow scrobes of ordinary type; face usually much longer than broad; vertex long; eyes large; tegmina without subapical cells, the veins of corium usually indistinguishable except by transmitted light .... **Nirvaniinæ.**

a^2. Antennæ situated at middle of eye margin (in facial view); lateral carinæ of vertex wanting; ocelli below anterior border of crown and not visible from above; head (from above) long spatulate, but not thin dorsoventrally; eyes not prominent, deep set in vertex; pronotum subtruncate posteriorly; tegmina with two subapical cells. **Stenometopiinæ.**

MACROCERATOGONIINÆ

Synopsis of genera.

a^1. Body not depressed; pronotum narrowly rounded between eyes; crown narrow basally, broadly rounded apically, the margin not notched over antennal scrobe; eyes set in middle of lateral margins of face (facial view), large; antennal flagella longer than body; loræ very broad; clypeus broadened apically; proboscis of moderate length; subcostal cell of tegmina without supernumerary cross veins (Macroceratogoniini) .... **Macroceratogonia** Kirkaldy.

a^2. Body more or less depressed; pronotum subtruncate or very broadly rounded between eyes; crown broad basally, obtuse angled apically, margin deeply notched over antennal scrobe; eyes set below middle of face, small; antennal flagella very short; loræ narrow; clypeus narrowed apically; proboscis very short; subcostal area with a number of supernumerary cross veins (Balbillini).

b^1. Body but slightly depressed; tegmina not strongly narrowed apically, the subcostal area not greatly broadened, or with strongly curved outer margin; tegmina membranous, venation distinct throughout. **Balbillus** Distant.

b^2. Body very strongly depressed; tegmina tectiform, strongly narrowed apically, the subcostal area expanded, and the outer margin strongly curved; tegmina subcoriaceous, venation obscure basally. **Stenotortor** g. nov.

Genus **MACROCERATOGONIA** Kirkaldy

Kirkaldy, Bull. Hawaiian Sugar Planters' Assoc. 1 (1906) 323.

Type, *Macroceratogonia aurea* Kirkaldy (Queensland).

Genus BALBILLUS Distant

Distant, Fauna Brit. India, Rhynch. 4 (1908) 287.

Type, *Balbillus granulosus* Distant (Ceylon).

The known range of this well-marked genus is now extended to Singapore and to British North Borneo. The relationships of *Balbillus* and *Macroceratogonia* seem to be unquestionable.

Balbillus albellus sp. nov. Plate 3, fig. 21.

Very pale ochraceous, the scutellum darker ochraceous with the apex blackish. Tegmina and wings milky translucent, subcostal and apical areas of tegmina subhyaline; small fuscous clouds covering apex of clavus, and apices of apical veins. Length, female, 6.75 to 7 millimeters; male, 5.5.

Whole front, to sides and extreme base, strongly flattened, delicately shagreened, the strongly curved lateral sutures of front distinct to their basal union beneath apex of vertex (Plate 3, fig. 21, *c*); genæ strongly extended beyond clypeus. Eyes small, width between them and front on either side greater than their width in facial view; face about as broad as long. Antennæ situated close under the margin of crown, the scrobe cutting through next eye to the upper surface of crown. Anterior margin of crown bordered by a sharp carina which is equivalent to the subocellar carina of *Pythamus;* the true vertex (Plate 3, fig. 21, *a*) is margined anteriorly by a curved carina which touches the border carina only at apex and curves backward toward, but does not connect with, the lateral carinæ of vertex, the indistinct ocelli being situated just within anterior extremities of latter, thus anterior to eyes and three times their diameter from latter. Length of crown a little less than interocular width, the basal margin straight, the lateral margins in front of eyes deeply angularly incised over the antennæ; delicate vestiges of a median carina occur only at base and before apex; median basal area smooth, remainder of surface more or less wrinkled and roughened. Length of pronotum nearly as great as that of vertex, the anterolateral margins into width about three times; surface smooth, depressed back of eyes, median basal area thickly microscopically transversely aciculate and sparsely punctate. Scutellum a little longer than pronotum, median basal area smooth, apical area minutely roughened, and suddenly elevated just before extreme apex, clavus smooth, subcostal area of corium subobsoletely wrinkled and punctured, stronger basally. Venation peculiar because of

the very small first apical cell, the very long, narrow, and similar second and third apicals, and the very large fourth apical cell; subcostal area with some light cross veins on distal half, which are distinct only by transmitted light. Subgenital plate of female with a small semicircular emargination behind.

STRAITS SETTLEMENTS, Singapore (*Baker*). Common. Judging from the published description and figure, this is very distinct from *B. granulosus* Distant of Ceylon. A larger form (length, 7.5 millimeters) of this species occurs at Sandakan, British North Borneo, and this is here designated var. *borneensis*.

These insects may be covered with white waxy powder, which readily rubs off.

Genus **STENOTORTOR** novum

Type, *Stenotortor inocarpi* sp. nov.

Characters as given in the generic synopsis. This genus represents a more highly specialized *Balbillus*. While the life habits of *Balbillus* are not known, it is to be presumed, from the greatly flattened face, very short proboscis, and more or less tectiform tegmina, that in a state of rest on the leaf the body is strongly appressed to the leaf surface, as in *Stenotortor*. Some of the striking structural modifications of both genera are correlated with this curious habit.

Stenotortor inocarpi sp. nov. Plate 3, fig. 22.

Pale brick red throughout, the face paler, the vertex and pronotum inclining to ochraceous. A broad fuscous-clouded band extends from basal margin of clavus to two-thirds its length on inner half, a short median fuscous spot in radial area, and a fuscous band occupying most of medial area and extended laterally to claval suture; base of third apical cell clouded with fuscous. Length, female, 5 millimeters; male, 4.75.

Differs from *Balbillus albellus* in structure as follows: Face a little wider than long, eye a little wider than temple in facial view (Plate 3, fig. 22, *c*). The antennæ, although close up under border of crown, yet possess a short, distinct, separated supra-antennal carina, which is lacking in *B. albellus*. The apical border carina of the true vertex is as strong as the border carina of crown and connects with the lateral carinæ before ocelli (Plate 3, fig. 22, *a*), the latter a little farther removed from lateral carinæ; anterior half of vertex distinctly depressed, posterior half plane; median carina distinct throughout, stronger apically.

Pronotum also coarsely subobsoletely transversely wrinkled on posterior area (as also on basal area of scutellum); length less than that of vertex, the anterolateral margin into width about three and a half times. Venation (Plate 3, fig. 23) similar to that of *Balbillus albellus* but first (inner) apical cell larger, second and third apical cells distinctly broadened distad, and fourth strongly narrowed distad; marginal vein indistinct around apex. Hind margin of subgenital plate of female with a deep narrow median slit.

STRAITS SETTLEMENTS, Singapore (*Baker*). The year 1918 spent in Singapore as assistant director of gardens, in association with a wonderful observer in the person of the director, Mr. I. H. Burkill, brought to my attention a world of marvelous biological novelties. The unique lecaniids living inside of twigs of *Macaranga* under the care of ants, many astonishing cases of ant-plant associations (in one of the latter cases accompanied by a symbiotic brenthid)—all of these and more can be studied to great advantage in the Botanic Gardens of Singapore. Not among the least of these interesting things do I count this beautiful little *Stenotortor*. In the economic gardens, near the office, stood a fine large introduced tree, *Inocarpus edulis,* of the Leguminosæ, the "Otaheite chestnut," supposed to have come from Polynesia. In passing beneath it from day to day, my attention was called to little red objects, tightly appressed to the surface of the leaves, and these I passed by for some time, supposing them to be scale insects affected by a red parasitic fungus, such affected scales being common in the gardens. One day, reaching up and touching one of them, I was astonished to see it leap quickly away. Closer examination revealed this unique jassoid insect. I do not know of any other adult jassid that can apply itself so closely to the leaf surface, although this habit is not uncommon among nymphs. The shade of its color is almost exactly that of the common scale fungus. It is thickly covered with brick red waxy powder which does not rub off easily. At rest on the leaf, the tegmina are much more widely, tectiformly outspread than in the mounted specimen. It will doubtless also be found on native Singapore Leguminosæ.

NIRVANIINÆ

Synopsis of genera.

a^1. Interocular portion of vertex never parallel sided; vertex broad, width between eyes greater than half width of pronotum, the latter never strongly narrowed cephalad; clypeus gradually a little narrowed to a broad subtruncate or slightly notched apex.

*b*¹. Sides of vertex strongly sinuate at middle of anteocular length; front with sides strongly incurved on basal half; lateral margins of front distant from the small eyes; brachypterous.
Didius Distant.[31]

*b*². Sides of vertex never strongly sinuate; front never with sides strongly incurved on basal half; lateral margins of front not far from the large eyes; all macropterous.

*c*¹. Ocelli distinctly nearer to each other than distance between eyes; medial cell strongly broadened apically, the sides never strongly incurved; vertex as long as, or usually shorter than, anteocular width........................ **Kana** Distant.

*c*². Ocelli as far apart as distance between eyes (rarely a little less) or farther; medial cell usually strongly narrowed apically, the sides more or less incurved; vertex as long as, or usually somewhat longer than, anteocular width.

*d*¹. Front depressed only apically; face above full and evenly convex, the oblique lateral folds low, broad, and indistinct; basal portion of median frontal carina not strongly raised.. **Nirvana** Kirkaldy.

*d*². Front depressed throughout or largely so; the narrow upper portion with conspicuous sharp oblique lateral folds; basal portion of median frontal carina more or less sublaminately raised.

*e*¹. Upper portion of disk of front without a strongly raised delimiting carina; length of vertex rarely as great as one and a half times anteocular width; ocelli rarely partially visible in facial view.

*f*¹. Vertex with the bordering carina weak and low, sinuate or obsolete at position of ocelli, which are raised on the rounded lateral margin so as to be plainly visible in lateral view; outline of vertex subtriangular with more or less strongly curved sides, but narrowing cephalad from very near eyes.
Pseudonirvana g. nov.

*f*². Vertex with the bordering carina strongly, thinly extended and raised, making the disk of the vertex rather strongly concave and usually hiding the ocelli in lateral view; outline of vertex broadly elliptical, usually equally broad for some distance in front of eyes........................ **Ophiuchus** Distant.

*e*². Upper portion of disk of front with a strongly raised and sharply delimiting carina; length of vertex more than twice anteocular width; ocelli clearly visible in facial view.
Nirvanoides g. nov.

*a*². Interocular portion of vertex with parallel sides; vertex narrow, width between eyes less than half width of pronotum, the latter strongly narrowly rounded anteriorly.

*b*¹. Vertex long, not broadened in front of eyes; clypeus suddenly narrowed to a rounded apex; loræ very short; face far longer than broad; head much narrower than pronotum; apical cells long and narrow, venation distinct throughout........................ **Pythonirvana** g. nov.

*b*². Vertex short, broadened in front of eyes; clypeus very gradually narrowed to a subtruncate apex; loræ narrow, but long; face as long

[31] *Didius* is provisionally placed in this subfamily.

as broad; head but slightly narrower than pronotum; apical cells short and strongly subtriangular; venation indistinct basally.
Jassonirvana g. nov.

Genus KANA Distant

Distant, Fauna Brit. India, Rhynch. 4 (1908) 285.

Type, *Kana thoracica* Distant (Ceylon).

Synopsis of species.

a^1. Apical cells long and narrow, subequal in length and width; tegmina with a median straight transverse finely dotted band and entire apical area (beyond cross veins) fuscous........................ **K. illaborata Distant.**

a^2. Apical cells shorter, very unequal in size and shape.

- b^1. Tegminal margin more or less evenly rounded apically; third apical cell (from within) large, trapezoidal, larger than second; appendix very small and narrow, sometimes almost indistinguishable.
  - c^1. Prevailing colors piceous and chestnut brown; frontal carina entirely wanting........................ **K. picea sp. nov.**
  - c^2. Prevailing colors pale ochraceous, with two black spots on apical area of tegmina; frontal carina present only on apical half of front........................ **K. maculata sp. nov.**
- b^2. Tegmina strongly sinuately margined at apex, the fourth apical cell with a pronounced teatlike extension at apex; third apical cell small, parallel sided, much smaller than second; appendix ample, especially at inner apical angle of tegmina; frontal carina present only on apical half of front........................ **K. anomala sp. nov.**

Kana illaborata Distant. Plate 3, figs. 24 and 25.

Distant, Fauna Brit. India, Rhynch. 4 (1908) 287.

Pale ochraceous; vertex and pronotum with irregular longitudinal stripes of white and yellow, on the vertex a median and two lateral white, two submedian yellow, on the pronotum a median, two submedian, and lateral margins white, and two submedian and two sublateral yellow; scutellum with basal median line, basal angles, and apical area pale yellow or whitish. Tegmina subhyaline, fuscous beyond apical cross veins, middle of corium and clavus crossed by a broad, straight, finely dotted pale fuscous band. Length of female, 6.5 millimeters.

Face (Plate 3, fig. 24, *c*) about as broad as long; entire disk of front flattened, the complete frontal carina at base suddenly broadened and coalescent with thickened upper margin of front. Front and clypeus basally shagreened, genæ sparsely punctate below eyes, irregularly rugose apically; supra-antennal carina sharp, passing obliquely straight to upper margin of eyes; the usual upper lateral ridges of face below border of vertex sharply carinate, one stronger than the rest extending above the supra-antennal carina, toward upper lateral angles. Crown (Plate 3,

fig. 24, *a*) somewhat longer than width between eyes, the lateral margins in front of eyes straight for a short distance; anterior border margined by a sharp carina—the subocellar carina of *Pythamus;* the ocelli are thus on the upper surface of the flat crown though subtended mesad by a delicate subobsolete sinuous carina which represents the supraocellar carina of *Pythamus;* ocelli nearly four times as far from each other as from lateral borders of crown and distinctly in front of anterior line of eyes; just within the anterior margin of crown is a sharp, narrow, concentric depression, giving the anterior margin somewhat the appearance of being reflexed; median carina sharp and complete, but less strong anteriorly; surface of vertex smooth. Length of vertex a little more than interocular width. Pronotum a fifth shorter than vertex, the anterolateral margins into width a little less than five times; hind border slightly incurved; a broad median area very finely thickly transversely aciculate, the remainder of surface smooth. Subgenital plate broadly obtuse-angularly extended at middle. Venation (Plate 3, fig. 25, *a*) of tegmina peculiar because of the very large and long apical cells of similar length, the second and fourth larger and of subequal breadth; appendix inconspicuous; venation of wing as in Plate 3, fig. 25, *b*.

BORNEO, Sandakan (*Baker*). STRAITS SETTLEMENTS, Singapore (*Baker*). This appears to be nothing more than a form of the species described by Distant from Tenasserim. It is common in North Borneo.

Kana picea sp. nov. Plate 3, fig. 26.

Black and piceous, shining; legs, anterior margin of crown, and abdomen except segmental margins pale ochraceous; scutellum, and clavus except two oblique black spots on inner margin at middle and extreme apex, chestnut brown. Tegmina piceous to apical cross veins except a small chestnut brown spot in cubital area at two-thirds its length, and a large subhyaline triangular area next outer margin apically, the inner point of this triangle reaching into radial cell, from this two oblique piceous stripes extending to apical margin; the margins of the subhyaline area, and the apical cross veins yellowish to reddish. Extremities of hind tibiæ and of first tarsal joint black. Length, female, 5 millimeters; male, 4.

Differs from *K. illaborata* in structure as follows: Face (Plate 3, fig. 26, *c*) a fourth broader than long; front similarly flattened but entirely without a median carina, whole surface very finely

thickly rugulose; clypeus shagreened medially near base, the lateral depressed areas extending nearly to base. Sculpture of face laterally at base very similar to that of *K. illaborata,* but the head beyond eyes much slenderer in side view. Crown (Plate 3, fig. 26, *a*) a fourth longer than width between eyes, the lateral margins of head suddenly prominent just beyond eyes; vestiges of supraocellar carina absent; median line shallowly incised, the median carina a fine line at bottom of incisure on basal half; whole surface of vertex slightly depressed but each lateral area gently convex, basal half nearly smooth except for a few scattering punctures, apical half coarsely shagreened and medially with minute longitudinal wrinkles; ocelli more than twelve times as far from each other as from lateral carina of vertex and much nearer this lateral carina than to eye. Pronotum on posterior two-thirds subobsoletely transversely wrinkled, anteriorly with two small submedian oval depressions; the length nearly two-thirds that of vertex, the anterolateral margins into width somewhat less than five times. Scutellum indistinctly irregularly wrinkled except at basal angles and with an indistinct median carina on basal area. Clavus and base of corium with scattering punctures from which arise minute white hairs stronger than usual. Venation (Plate 3, fig. 26, *d*) similar to that of *K. illaborata,* but the apical cells shorter. The male differs in being very much smaller, with the crown somewhat shorter and less strongly rounded anteriorly.

LUZON, Benguet Subprovince, Baguio (*Baker*). This beautiful species is closely related to other species of *Kana* in essential characters, but differs sharply in certain details of sculpture and in the absence of frontal carina.

Kana maculata sp. nov. Plate 3, fig. 27.

Pale ochraceous, lateral margins of pronotum broadly yellowish; a fuscous band extends from anal margin of clavus, straight in line of long axis of tegmina, across clavus, and terminates in corium near apex of medial area; apices of radial and medial areas reddish; from apex of radial area three narrow fuscous stripes extend outward and proximad to costal margin; three inner apical cells largely yellowish; a black spot at apex of outer apical cell, another smaller one on the inner apical vein. A small black spot on the lateral surfaces of the pygofers. Length of female, 5.5 millimeters.

Differs from *K. illaborata* in structure as follows: Frontal carina recognizable only on anterior half of front. Lateral mar-

gins of head in dorsal view angulately prominent in front of eyes. Vertex nearly as in *K. picea;* length less than width. Pronotum (Plate 3, fig. 27, *a*) four-fifths the length of vertex, the anterolateral margin unusually long, into the width four times; the surface entirely smooth except for a few scattered punctures on basal area. Scutellum very minutely roughened. Venation similar to that of *K. picea,* but apex of tegmina and apical cells of different form (Plate 3, fig. 27, *b*). Subgenital plate medially deeply roundly emarginate.

LUZON, Laguna Province, Mount Maquiling (*Baker*). A conspicuous but apparently rare species from the forest.

Kana anomala sp. nov. Plate 3, fig. 28.

Pale ochraceous; the vertex margined at sides and in front with a white waxy band, within this a reddish band; pronotum, scutellum, and a large part of tegmina pale reddish brown; entire subcostal area broadly albescent, this having a straight transverse fuscous stripe at its apex and four equally spaced oblique fuscous stripes crossing its field, the first being near to base; the outer cross vein is bordered with red, and a small yellow spot occurs on the fourth oblique fuscous stripe; broad longitudinal vermiculately fuscous bands extend, one along inner two-thirds of clavus, and one along middle of corium, these connecting apically where they form a broader median patch; apex of clavus and small dots at bases of two inner apical cells black; small albescent patches occur before the three inner apical cells and in apical area of clavus; the teatlike extension of outer apical angle of tegmina and a large patch at inner apical angle fuscous. Apex of first hind tarsal joint and a spot on the lateral face of each pygofer black. Length, female, 6.75 millimeters; male, 4.5.

In the male, which presents the usual difference in form of head, the longitudinal vermiculately fuscous bands of tegmina are wanting, the area of reddish brown thus being greater; the first (basal) oblique stripe in subcostal area is wanting, and the black and albescent markings near bases of apical cells are wanting.

Differs from *K. maculata* in structure as follows: Vertex more as in *K. illaborata,* the surface not at all incised at median line, the median carina distinct on basal half; length of vertex (Plate 3, fig. 28, *a*) a little greater than width between eyes; ocelli situated nearly as in *K. picea.* Pronotum nearly smooth throughout, but with faint, minute indications, medially, of

transverse wrinkles; the length is three-fourths that of vertex, the anterolateral margin into width somewhat more than four times; the hind margin broadly incurved. Tegmina with a teat-like extension of the exterior apical angle very strongly marked in the female (Plate 3, fig. 28, *b*), less so in the male; appendix apically broad and conspicuous as compared with the narrow and inconspicuous appendices of other species. Subgenital plate with hind margin subtruncate, slightly bisinuate.

LUZON, Laguna Province, Mount Maquiling (*Baker*). The most beautifully marked of the species herein treated and remarkable for the highly developed and unique sexual differences. It will be noted that the sexual differences here are much more profound in both structure and coloration than are given by Distant to separate the "species" *K. thoracica* from *K. ramificata* and *K. illuminata* from *K. signata,* for which are given no sexual or structural characters not within the bounds of sexual differences usual in this genus.

Genus **NIRVANA** Kirkaldy

Kirkaldy, The Entom. **33** (1910) 293.

Type, *Nirvana pseudommatos* Kirkaldy (Ceylon).

Without a careful study of the type species, which I do not possess, it is impossible to be certain of the limits and position of this genus. The description of Kirkaldy is entirely inadequate, as to both genus and species, to distinguish it certainly among the great number of Oriental forms, without specimens for comparison. Melichar, in working up the Homoptera of Ceylon, did not have Kirkaldy's species but considered *N. pallida* Melichar as certainly congeneric and amended the generic description from that species. Two Far Eastern species, *N. philippinensis* sp. nov. and *N. placida* Stål, are certainly congeneric with *pallida* (indeed, *pallida* is probably synonymous with *placida*), so that I have taken these two species as typical of true *Nirvana.* They agree fairly with descriptions and with Melichar's figures. *Nirvana suturalis* Melichar is doubtfully congeneric, as is also *N. insignis* Distant. *Nirvana decora* Melichar may be a *Kana.* Three of Distant's species, *N. greeni, N. longitudinalis,* and *N. linealis,* appear to belong to *Pseudonirvana;* the second certainly does.

Synopsis of species.

a^1. Tegmina with a small fuscous dot at base of second apical cell; costal area with two oblique fuscous stripes; vertex and pronotum with a

broad median ivory white line; vertex largely thickly finely longitudinally wrinkled .... **N. placida** Stål.

a^2. Tegmina with a large round deeply black spot at base of second apical cell; costal area with three oblique fuscous stripes; vertex and pronotum with a fine median black line; vertex largely smooth, sparsely wrinkled anteriorly........ **N. philippinensis** sp. nov.

Nirvana placida Stål. Plate 4, figs. 29 and 30.

Stål, Freg. Eng. resa Ins. (1859) 295 (*Jassus* sub *Deltocephalus*).

It was with no little pleasure that I collected in Singapore and Penang large series of this species, described by Stål in 1859 and unrecognized since. Stål recorded it from Singapore and Hongkong, and I have it also from Sandakan, North Borneo. Specimens received from Matsumura, collected in Formosa, and bearing the name *Nirvana pallida* Melichar are the same species. Matsumura also records it from Riu Kiu.[32] It appears to be actually *N. pallida* Melichar, so far as can be judged from descriptions and figures, though careful comparison should be made with Ceylonese specimens. This species shows a strong sexual dimorphism in the head (Plate 4, figs. 29 and 30), though the tegmina in the two sexes are practically identical.

The structure of this species is very similar to that described below for *N. philippinensis*. Only the median basal portion of vertex is smooth, the rest of the surface being occupied by thick fine longitudinal wrinkling. The pronotum and scutellum are smoother. The vertex in the male (Plate 4, fig. 30, *a*) is a little shorter and more acute than in the female (Plate 4, fig. 29, *a*). In a male tegmen (Plate 4, fig. 30, *b*) the two oblique cross veins in subcostal area are distinct; in a female tegmen (Plate 4, fig. 29, *d*) these are quite indistinguishable.

Nirvana philippinensis sp. nov. Plate 4, fig. 31.

Very pale ochraceous; the delicate complete median carina of vertex is black, and a median stripe a little paler in color continues across the pronotum and scutellum, and in some specimens the full length of claval commissure; ocellus seated in an orange spot. Tegmina milky translucent, three oblique fuscous stripes over the corresponding cross veins in apical half of subcostal area; a large orange spot covers apical portions of radial and medial areas; apical submargin fuscous, this extending into outer apical cell; a large round black spot at base of second apical cell; extreme apex of clavus fuscous. Length, female, 5 millimeters; male, 4.25.

[32] Trans. Sapporo Nat. Hist. Soc. 1 (1905) 21.

Face finely shagreened, the front rather strongly evenly convex and with a fine complete median carina. Basal lateral area of face sculptured as in *Kana illaborata*. Vertex (Plate 4, fig. 31, *a*) about one and a half times as long as wide between eyes, the curve of lateral margin of head even from the eyes to the subangulate apex. Ocellus on the rounded curved anterior border passing to the front, about four times its diameter from eye; the sharp fine carina bordering anterior margin of vertex becomes weak near ocellus, passes above it and is lost in the callose lateral margin of vertex adjoining eye; there is a distinct subocellar carina just below the ocellus which joins and is continuous with the supraocellar carina some distance beyond ocellus; the condition is, therefore, comparable with that in *Pythamus*. Surface of vertex slightly depressed, gently convex, basal two-thirds smooth, apical third sparsely weakly longitudinally wrinkled, the raised callose lateral margins next to eyes rugose. Pronotum two-thirds length of vertex, the anterolateral margins into width somewhat more than three times; basal two-thirds subobsoletely transversely wrinkled and sparsely punctate. Scutellum minutely rugose except the shagreened basal angles. Apical cells in tegmina distinctly larger than in *N. placida*.

LUZON, Laguna Province, Los Baños and Mount Maquiling (*Baker*). MINDANAO, Surigao Province, Surigao: Lanao Province, Kolambugan: Zamboanga Province, Dapitan (*Baker*). This very abundant species is remarkably uniform in characters throughout the lowlands. At Baguio, Benguet, Luzon, in the high mountains, it differs by having the claval commissure broadly black and the orange at apex of radical and medial areas extending more or less toward the costa between the oblique fuscous stripes. This form is designated var. *montana*.

Genus **PSEUDONIRVANA** novum

Type, *Pseudonirvana sandakanensis* sp. nov.

Characters as given in the synopsis of genera. This genus includes a number of species formerly referred to *Nirvana*, as remarked under that genus. It appears to be richer in species than any other genus of the family and to be distributed throughout the Indo-Malayan countries.

Synopsis of species.

a^1. Ocelli very large and prominent; second and third apical cells subequal in length and parallel sided, their basal cross veins in line or nearly so; tegmina largely reddish yellow, with three long oblique stripes

in subcostal area and a large dark fuscous cloud over third apical cell; vertex nearly smooth.. **P. ocellaris sp. nov.**

*a*². Ocelli medium to small; second and third apical cells not subequal in length and parallel sided, their basal cross veins usually strongly dislocated.

*b*¹. Median carina strikingly different on anterior and posterior halves of vertex; outer apical vein in tegmina strongly curved or sinuate; vertex and tegmina apically without large black spot.

*c*¹. Tegmina long and slender; outer apical vein strongly outcurved; second apical cell with subparallel sides; head distinctly narrower than pronotum, two oblique subcostal stripes; median carina of vertex strong on anterior half, on basal half appearing as a fine line set in an incisure; vertex in large part with wrinkled surface. **P. penangensis sp. nov.**

*c*². Tegmina rather short and broad; outer apical vein strongly bisinuate; second apical cell strongly broadened apically; head nearly as broad as pronotum; three oblique subcostal stripes; median carina of vertex obsolete on anterior half; vertex in large part smooth.. **P. singaporensis sp. nov.**

*b*². Median carina of vertex complete and equally strong throughout.

*c*¹. Vertex nearly smooth except for a few indistinct wrinkles.

*d*¹. Outer apical vein very strongly curved; head and tegmina apically without large round black spots; vertex with a median yellowish line; anterolateral margin of pronotum much longer than posterolateral.. **P. malayana sp. nov.**

*d*². Outer apical vein straight or nearly so; with a large round black spot near apex of tegmina; anterolateral and posterolateral margins of pronotum subequal.

*e*¹. Vertex with an apical black spot; apex of tegmina evenly rounded; first apical cell long and narrow. **P. sandakanensis sp. nov.**

*e*². Vertex with a subapical transverse sanguineous band bent caudad at sides; apex of tegmina somewhat emarginate beyond first and second apical cells (? in male); first apical cell very broad................................ **P. sanguineolineata sp. nov.**

*c*². Vertex in large part strongly conspicuously longitudinally wrinkled; anterolateral margins of pronotum much longer than posterolateral.

*d*¹. Black spot of vertex apical, preceded by a single median dark line; vertex narrow, sides of head outcurved beyond eyes; first apical cell long, second very large and broad, third very small. **P. davaoensis sp. nov.**

*d*². Black spot of vertex subapical, preceded by two submedian black lines; vertex broad, side of head not outcurved beyond eyes; first apical cell short, second small and narrow, third very large. **P. longitudinalis** Distant.

Pseudonirvana ocellaris sp. nov. Plate 4, fig. 32.

Very pale ochraceous; a small short transverse mark just before apex of vertex and anterior half of median carina reddish; sides of vertex and basal median area of pronotum clouded

with orange yellow; median basal area of scutellum lemon yellow. Tegmina with subcostal and apical areas hyaline, remainder orange yellow tinged with reddish apically; three oblique stripes in subcostal area and a costal dot distad of these fuscous; inner apical angle of second apical cell, nearly all of third, and apex of outer apical cell dark fuscous, this colored field very much darker basally. Length of male, 5 millimeters.

Front broadly flattened to extreme base, the sides not convexly rounded, and with a strong median carina which is a little raised near base; surface shagreened. Basal lateral areas of face nearly as in *P. malayana.* The very large and prominent ocellus lies close to inner extremity of bordering carina and a little more than its own diameter from eye. Length of vertex one and a half times interocular width, the inner margins of eyes strongly convergent caudad, sides of head protuberant in front of eyes; surface of vertex gently broadly concave, smooth except for scattering punctures, lateral folds minutely rugose. Length of pronotum (Plate 4, fig. 32, *a*) a little more than half that of vertex, the anterolateral margins into width about five times; surface appearing smooth but basal area very minutely transversely aciculate. Basal area of scutellum smooth. Venation (Plate 4, fig. 32, *b*) peculiar because of the position of the two oblique veins in subcostal area, these being farther than usual from apical cross veins; the subequal second and third apical cells with subparallel sides, and the cross veins at their base more or less nearly in line.

BORNEO, Sandakan (*Baker*). Remarkably distinct by the ocelli and the coloration.

Pseudonirvana penangensis sp. nov. Plate 4, fig. 33.

Very pale ochraceous, entirely without black markings; a small cloud before apex of vertex, and anterior half of median carina reddish. Tegmina subhyaline, inner half and apical veins tinted with yellowish; two faint oblique lines on apical half of subcostal area. Length of male, 5 millimeters.

Differs in structure from *P. davaoensis* as follows: Basal areas of sides of face as in *P. sandakanensis;* depression of front falling considerably short of reaching base of face. Ocellus situated in a small depression almost in line of bordering carina of vertex, and its own diameter from eye, the bordering carina becoming indistinct, about once the diameter of the ocellus before it, and sending indistinct branches both below and above it. Length of vertex (Plate 4, fig. 33, *a*) about one

and two-thirds times width between eyes; surface evenly gradually depressed, the basal half of median carina set in a shallow incisure; median basal area smooth with a few punctures, the remaining area thickly finely longitudinally wrinkled. Length of pronotum about half length of vertex, anterolateral margin into width about four times. Venation (Plate 4, fig. 33, *b*) peculiar because of the long narrow parallel-sided second apical cell, and the strongly outcurved third apical vein, in this resembling *P. ocellaris*.

STRAITS SETTLEMENTS, Penang Island (*Baker*).

Pseudonirvana singaporensis sp. nov. Plate 4, fig. 34.

Very pale ochraceous throughout, with no black markings. Tegmina hyaline, with the usual three transverse fuscous stripes in subcostal area, but in this case very faint. Length of female, 6 millimeters.

Differs from *P. penangensis* in structure as follows: Frontal depression reaching nearly to extreme base of face. Ocellus small, twice its diameter from eye, situated in a depression distinctly behind the bordering carina of front and behind the thickened margin, the bordering carina anterior to ocellus being lost in numerous fine wrinkles, and about apex of vertex very weak. Vertex (Plate 4, fig. 34, *a*) large and broad, length nearly one and a half times the interocular width, the width of the whole head being nearly that of pronotum; anterior half of median carina of vertex obsolete, posterior half finer and set in a shallow incisure; surface evenly depressed, smooth except narrowly before apical margin where it is indistinctly longitudinally wrinkled. Length of pronotum half that of vertex, the anterolateral margins into width about six times. Venation (Plate 4, fig. 34, *b*) peculiar because of the long trapezoidal second apical cell, and the strongly sinuate outer apical vein.

STRAITS SETTLEMENTS, Singapore (*Baker*). This cannot be the other sex of *P. penangensis* due to the widely different structure, although they are somewhat superficially similar in entirely lacking strong color markings.

Pseudonirvana malayana sp. nov. Plate 4, fig. 35.

Very pale ochraceous; face medially ochraceous, margins whitish; apical submargin of vertex with a blood red transverse line; side margins of vertex and apical half of median line washed with yellowish; lateral areas of vertex divided medially by a broad longitudinal ivory white band (the two diverging

cephalad), the latter continued across pronotum and on to scutellum. Tegmina hyaline, with the usual three fuscous stripes in subcostal area, the space between the second and third of these and the apical veins more or less yellow. Length, female, 6 millimeters; male, 5.

Basal lateral areas of face about as in *P. longitudinalis*, with the remarkable difference that the carinate wrinkle, which passes obliquely upward to subtend the ocellus in that species, here joins the bordering carina of vertex, the ocellus lying above the bordering carina, the latter beyond this point and toward the eye being lost in many fine longitudinal wrinkles; the ocellus is small and more than its own diameter distant from the eye. The length of vertex (Plate 4, fig. 35, *a*) is one and a half times the interocular width; median carina on basal third fine and set in an incisure; surface broadly slightly depressed, largely smooth, indistinctly wrinkled or rugose near apical margin and in basal angles. Median basal area of scutellum smooth. Venation (Plate 4, fig. 35, *b*) peculiar in the distally narrowed second apical cell and in the strongly outcurved third apical vein.

BORNEO, Sandakan (*Baker*). STRAITS SETTLEMENTS, Penang Island and Singapore (*Baker*). In coloration of head and pronotum this common Malayan species resembles *P. sanguineolineata*, and in venation, *P. penangensis*, but is distinct otherwise. As usual, the head of the male is a little shorter and more pointed. Three males from Penang (normal males are common there) have the whole upper surface strongly suffused with golden yellow, and this form is designated var. *auricolor*.

Pseudonirvana sandakanensis sp. nov. Plate 4, fig. 36.

Very pale ochraceous; a small apical cloud on vertex and anterior half of median carina reddish or blackish. Tegmina subhyaline, an irregular faintly orange cloudy band extending transversely from apex of clavus to costa; three fuscous stripes in subcostal area in usual position, the first faintest; a large round black spot lying half in second apical cell and half in third. Length of female, 4.25 millimeters.

Differs from *P. davaoensis* in structure as follows; Median frontal carina a little raised basally. Sculpture of basal lateral areas of face similar to that of *Kana illaborata* instead of *Pythamus*. Ocellus situated above the carina which actually borders anterior margin of crown, but a short branch of this carina passes to inner border of ocellus. Length of vertex (Plate 4, fig. 36, *a*) about one and a half times interocular width, the

vertex and pronotum as a whole much broader in proportion to width than in *P. davaoensis;* median carina equally strong throughout but not quite reaching apex of vertex; lateral areas strongly depressed, especially basally; surface smooth, with few scattering punctures. Pronotum half the length of vertex, anterolateral margins into width a little more than six times; hind margin broadly subangularly emarginated. Venation (Plate 4, fig. 36, *b*) peculiar in the small and apically narrowed second apical cell.

BORNEO, Sandakan (*Baker*). This small species is a conspicuous case of a common condition in this family, of species so closely resembling others in colors that they might be placed together on superficial examination, and yet be totally distinct structurally.

Pseudonirvana davaoensis sp. nov. Plate 4, fig. 37.

Very pale ochraceous; a large black spot at apex of vertex; sides of head in front of eyes slightly yellowish. Tegmina clear hyaline; three fuscous subcostal stripes in the usual position of the cross veins, the first faintest; a large round black spot entirely within the large second apical cell. Length of female, 4.5 millimeters.

Disk of front plane, sides roundly convex, surface coarsely shagreened, the fine central carina weaker at the middle, stronger above where it is not raised. Ocellus visible in either dorsal or facial view, on the lateral border of head and beneath the continuous strong supraocellar carina, which borders the entire margin of vertex; a subocellar carina extends strongly obliquely downward from apex of front as in *Pythamus;* the ocellar area is narrow and has several transverse wrinkles within; the upper lateral carina of front passes from near end of supra-antennal carina obliquely upward and toward apex; supra-antennal area smooth. Vertex (Plate 4, fig. 37, *a*) twice as long as interocular width, the lateral margin of head a little outcurved before eyes; the fine median carina complete, slightly stronger basally; the surface not depressed medially, little depressed along lateral margins, basal half smooth, with scattering minute punctures, apical half minutely irregularly wrinkled. Pronotum a little less than half length of vertex, anterolateral margins into width a little less than three and a half times, the anterolateral margins much longer than posterolateral; with or without a delicate median dark line; surface smooth except for subobsolete wrinkles on median basal area

and a few scattering minute punctures; hind margin shallowly subangularly emarginate. Basal area of scutellum smooth. Venation (Plate 4, fig. 37, *c*) peculiar in the very large second apical cell and subtriangular third.

MINDANAO, Davao Province, Davao (*Baker*). A single specimen from Mount Maquiling, Laguna Province, Luzon, agrees with the Davao specimens in all structural and color characters except that the vertex and pronotum are white waxy; the tegmina are opaquely albescent, with an orange-colored patch at apex of radial and medial areas, and the space between second and third subcostal stripes is fuscous. This form is here distinguished as var. *luzonensis*.

Pseudonirvana sanguineolineata sp. nov. Plate 4, fig. 38.

Very pale ochraceous; vertex apically with a submarginal arcuate violet stripe, which reaches the lateral margins and thence extends narrowly caudad to become lost in the lateral longitudinal orange stripes of vertex; median carina violet; two ivory white submedian longitudinal stripes become slender in diverging cephalad. Pronotum and scutellum with two submedian ivory white longitudinal stripes, these more or less diffuse on scutellum. Tegmina subhyaline; an irregular orange area occurs in the apices of radial and medial areas; from the incurved outer margin of radial area three cross veins extend to costal margin, the first two oblique, the last transverse and these and the outer apical vein are more or less clouded with fuscous; a large round black spot nearly fills the second apical cell and extends into the third. Wings albescent, strongly iridescent apically. Length of female, 5.25 millimeters.

Front plane, coarsely shagreened, the median carina fine, subobsolete at middle, more distinct basally where it is strongly raised. Sculpture of basal lateral areas of face similar to that of *Kana illaborata*. Ocellus on the lateral rounded border of vertex and turned outward, the sharper carina bordering crown anteriorly passing below it, a very short branch of this from in front of ocellus reaching its posterior border. Length of vertex (Plate 4, fig. 38, *a*) about one and three-fourths times the width between eyes; lateral margins of head before eyes gradually converging cephalad to a broadly rounded apex; surface a little depressed, nearly plane, indistinctly shagreened, the rounded lateral margins rugose, before apex with a few very fine and indistinct longitudinal wrinkles; the median carina does not quite reach the apex. Pronotum about half the length of

vertex, the anterolateral margins scarcely longer than posterolateral and into width about five times; the surface smooth and shining, the basal area with subobsolete transverse wrinkles and a few widely separated punctures. Scutellum with median basal area subobsoletely transversely wrinkled and apical area subobsoletely rugose. Venation as shown in Plate 4, fig. 38, *b;* the first oblique cross vein may be indistinguishable; extreme apex of tegmina shallowly emarginate, though this will probably prove to be less well marked in the male.

BORNEO, Sandakan (*Baker*). PALAWAN, Puerto Princesa (*Baker*). The Palawan specimens are specifically identical with those from Borneo.

Pseudonirvana longitudinalis Distant. Plate 4, fig. 39.

Distant, Fauna Brit. India, Rhynch. 4 (1908) (*Nirvana*).

This species is described from Tenasserim. Later, in the same work,[33] it is recorded from Burma. Through recent collections, we can extend its known range through Penang and Singapore to Sandakan and also to Hongkong.

The depth of coloring varies, but the markings are the same in all specimens. The face shows a strong similarity to that of *P. singaporensis*. Structures near the ocellus are peculiar; the oblique wrinkles of basal lateral portions of face are few and very strong, carinalike; from among them a strong carina passes toward upper margin of eyes and closely subtends the ocellus below; this carina is parallel to the supra-antennal carina, leaving between them a smooth narrow channel; border carina of vertex becoming subobsolete a short distance before ocellus, sending delicate branches above and below it; the ocellus lies in the line of the bordering carina and about its own diameter from eye. Length of vertex (Plate 4, fig. 39, *a*) about one and a half times interocular width; the anterior black spot may be emarginate apically; surface subdepressed apically, elsewhere gently convex, smooth medially on basal area, the remaining surface thickly longitudinally or obliquely wrinkled. Length of pronotum about two-thirds the length of vertex, anterolateral margins distinctly longer than posterolateral, and into width about three and a half times; surface sculptured as in other members of this group. Venation (Plate 4, fig. 39, *b*) peculiar in the narrow and somewhat curved second apical cell and the very large third apical cell.

[33] Op. cit. 7 (1918) 33.

Genus **OPHIUCHUS** Distant

Distant, Fauna Brit. India, Rhynch. 7 (1918) 33.

Type, *Ophiuchus princeps* Distant (Travancore).

There is nothing given in the generic descriptions of Distant by which the many species of the Nirvaniidæ can possibly be separated into generic groups. There is every gradation in size of vertex and in curve of outer margin. I have, therefore, selected from my material two new species which seem to be congeneric with *O. princeps* Distant, and have distinguished this group of species as stated in the synopsis of genera. These two species possess a type of venation which distinguishes them from all other known members of this family. But Distant does not describe the venation or show it in his figure. A third new species (*O. marginatus*) is doubtfully placed in this genus. Nothing more than this can be done until the type species is redescribed and its details are figured.

Synopsis of species.

a^1. Two apical cross veins nearly in line transversely, the two subcostal cross veins joining radial vein far proximad of apical cells.
- b^1. Anterolateral margins of pronotum but slightly longer than posterolateral; a large blood red subapical spot in tegmina, the two subcostal oblique stripes subparallel............................ **O. basilanus** sp. nov.
- b^2. Anterolateral margins of pronotum about three times the length of posterolateral; vertex broadly margined laterally with red, these stripes passing caudad over pronotum and scutellum and following the commissural margins to end of clavus; the two subcostal oblique stripes converging mesad........................ **O. montanus** sp. nov.

a^2. Two apical cross veins distinctly dislocated; two subcostal cross veins joining radial vein near apical cell........................ **O. marginatus** sp. nov.

Ophiuchus basilanus sp. nov. Plate 5, fig. 40.

Pale ochraceous; bordering carina of vertex and anterior two-thirds of median carina black; sides of vertex broadly reddish yellow; pronotum and tegmina (the latter subhyaline) suffused with pale clear golden yellow. Pronotum with a median fuscous line. Tegmina with the subcostal area apically clear hyaline and crossed by two oblique fuscous stripes; a roundish blood red patch lying half in basal portion of second and half in basal portion of third apical cell. Length of male, 6 millimeters.

Front strongly flattened to extreme base, the fine median carina there suddenly stronger, the head as a whole (Plate 5, fig. 40, *b*) vertically very thin. Supra-antennal carina strongly

sharply elevated, the entire area between this and bordering carina of vertex nearly smooth, the frontal folds scarcely invading it. The very small ocellus lies just within the border carina of vertex, its own diameter distant from this carina, and some four times its diameter from eye. Length of vertex (Plate 5, fig. 40, *a*) little more than one and a half times interocular width, its surface plane anteriorly, depressed at sides basally, median basal area smooth, remainder finely longitudinally wrinkled. Length of pronotum into that of vertex two and a fourth times, the anterolateral margins much longer than posterolateral and into width a little less than four times; surface nearly smooth, with a few widely scattered punctures; hind margin broadly subangularly emarginate. Median basal area of scutellum nearly smooth. Tegmina subacutely pointed at apex of third apical cell, the second apical cell strongly narrowed distad, the third very large, the two cross veins in subcostal area far removed from apical cell, the two apical cross veins nearly in line. Head nearly as wide as pronotum.

BASILAN (*Baker*).

Ophiuchus montanus sp. nov. Plate 5, fig. 41.

Pale ochraceous, border carina and median carina of vertex brownish; vertex with slender submarginal reddish stripes. Pronotum with a fuscous median line and two broad submedian longitudinal reddish bands which extend across basal angles of scutellum. Tegmina subhyaline, the veins ochraceous, the two cross veins in subcostal area slightly darkened; anal margins and commissural margins of clavus broadly red, these bands extending obliquely from apex of clavus to apex of medial area. Length of male, 6 millimeters.

Differs from *O. basilanus* in structure as follows: The ocellus larger, its own diameter distant from border of crown, and about thrice its diameter from eye. Length of vertex (Plate 5, fig. 41, *a*) one and a third times the interocular width, its entire area evenly shallowly depressed, smooth only medially at extreme base, entire remainder of surface finely longitudinally obliquely rugosely wrinkled. Length of pronotum into that of vertex one and a half times, anterolateral margins far longer than posterolateral and into width a little more than three times; posterior two-thirds of surface densely very finely transversely aciculate, with a few scattering punctures at sides.

LUZON, Laguna Province, summit of Mount Maquiling (*Baker*).

Ophiuchus marginatus sp. nov. Plate 5, fig. 42.

Pale ochraceous; vertex with an arcuate violet mark just before apex, the median line and lateral margins to apex broadly reddish. Pronotum with a median band basally, and broad submedian longitudinal bands, reddish, the latter extending across basal angles of scutellum. Tegmina hyaline, basal area clouded with pale golden yellow, basal and commissural margins of clavus broadly reddish. Length, 6.5 millimeters.

Differs from *O. basilanus* in structure as follows: Supra-antennal carina not so strongly raised, the space between it and border of carina broader, and traversed medially by a slender carinate wrinkle. While the general outline of the head is similar to that in other species, the course of the border carina and the accompanying structures are entirely different; the border carina curves inward before ocellus and has lying within it a delicate sinuate carina which passes mesad of the ocellus; the ocellus is less than its own diameter from either of these carinæ and about three times its diameter from eye. Length of vertex (Plate 5, fig. 42, *a*) a little less than one and a third times the interocular width; surface nearly plane and entirely smooth except for a few indistinct longitudinal wrinkles before apex. Tegmina (Plate 5, fig. 42, *c*) more broadly rounded apically, the outer apical vein strongly curved, the two cross veins in subcostal area lying close to apical cell, and the two apical cross veins strongly dislocated.

STRAITS SETTLEMENTS, Singapore (*Baker*). This species differs so widely from the two preceding species that it is placed in *Ophiuchus* with some doubt. The structure of the vertex is unique, and the venation is very different in detail from that of the other species.

Genus **NIRVANOIDES** novum

Type, *Nirvanoides amboinensis* sp nov.

Characters as stated in the generic synopsis. This genus represents an extreme development of the *Nirvana* type of jassoid insects, similar to the African *Atritona* Melichar as to length of head, though in that genus the outline of apex of head is very obtuse, almost truncate.

Nirvanoides amboinensis sp. nov. Plate 5, fig. 43.

Very pale ochraceous; vertex with a black point at apex, and from this extend caudad two delicate submedian black lines, widest apart on anterior half of vertex and gradually converg-

ing caudad to the transverse furrow of scutellum. Tegmina translucent, subcostal area hyaline and apically with two widely separated pale fuscous oblique stripes, the second near to apex. Length, female, 6.5 millimeters; male, 5.25.

Front strongly flattened to extreme base and nearly to lateral margins, the narrow sides convexly rounded; the delicate median carina is stronger and considerably raised at base. Basal lateral areas of face somewhat as in *Pseudonirvana longitudinalis*, but the supra-antennal area broader; the minute ocellus is situated beneath the bordering carina and about four times its diameter from eye; the bordering carina is weak just before ocellus and becomes obsolete behind it where it is lost in the minute wrinkles on lateral fold of vertex. Length of vertex (Plate 5, fig. 43, *a*) two and a half times interocular width; surface evenly gently concave, smooth except for scattering punctures, and usually white waxy pulverulent. Length of pronotum equaling interocular width, anterolateral margins far longer than posterolateral, and into width little more than two and a half times; anterior margin unusually broadly rounded. Scutellum very large, longer than pronotum, the median basal area smooth. Venation (Plate 5, fig. 43, *d*) peculiar because of the very large and long second apical cell, which is narrowed apically, and the small, short third apical, which is strongly broadened apically; in the male (Plate 5, fig. 43, *c*) one cross vein in subcostal area may be quite distinct, while in the female both cross veins may be indistinguishable. Subgenital plate of female with hind margin truncate as in most species of this family.

AMBOINA (*Muir*). During his Moluccan travels, Mr. Muir found this species only on Amboina.

Genus **PYTHONIRVANA** novum

Type, *Pythonirvana muiri* sp. nov.

Characters as given in the generic synopsis, combining some of the characters of *Pythamus* and *Nirvana* and yet widely distinct from both. It is in many respects a connecting link between them.

Pythonirvana muiri sp. nov. Plate 5, fig. 44.

Shining black; venter with lateral abdominal margins (except subgenital plate and genitalia), legs, and antennæ pale ochraceous; a small oval yellow spot next to margin on either side of vertex halfway between ocellus and apex; a large triangular lemon yellow spot at middle of clavus, its long side on the

commissure; toward apex of tegmina the black becomes deep fuscous. Length, female, 5.5 millimeters; male, 5.

Head from above with the appearance somewhat of *Nirvana*, but viewed from side deep throughout, the lower frontal line concave. Length of face (Plate 5, fig. 44, *c*) one and two-thirds times the width, the front more than two times longer than wide; clypeus strongly narrowed to apex; loræ minute. Front rugose-punctate on the concave apical half and coarsely obliquely wrinkled on the strongly protuberant basal half. Supra-antennal carina strong, oblique, and some distance above insertion of antennæ, the supra-antennal area smooth; basal lateral areas of face with the lateral oblique folds strongly carinate, one of these carinæ extending toward upper margin of eye, closely subtending the ocellus, and joining bordering carina near eye, leaving between it and the bordering carina a deep narrow lateral sulcus in which the ocellus is located, the latter some five or six times its diameter from eye. Length of vertex (Plate 5, fig. 44, *a*) a little less than twice interocular width, surface deeply concave, a little raised toward median line where there is a strong uniform median carina reaching to near apex; the bordering carina is sharp, strongly raised, incurved above ocellus, and continuous with lateral carina to base of eyes, the obtuse lateral folds of *Nirvana* being here high and sharp; interior surface smooth, except for scattered punctures, and irregular wrinkles on lateral slopes; basal margin of vertex not carinately raised; lateral margins parallel. Length of pronotum into vertex one and a half times, the anterolateral margins distinctly longer than posterolateral, into width three and a half times; hind margin broadly subangularly emarginate; larger part of surface very coarsely transversely rugose-punctate, coarsely punctate apically and with two small smooth areas behind eyes. Median basal area of scutellum coarsely rugose-punctate, apical area minutely rugose. Basal portion of clavus and base of subcostal area closely coarsely punctate; veins bordering radial and medial areas distinct except at base; first, second, and third cells regularly gradated in length, the third shortest; one oblique cross vein in subcostal area. Head much narrower than pronotum.

BORNEO, Sandakan (*Baker*). AMBOINA (*Muir*). The single specimen taken by Mr. Muir in Amboina is identical with the Sandakan specimens. With the narrow head and the coarse sculpture, this has a remarkable resemblance to *Pythamus*, and yet it is properly one of the Nirvaniidæ.

Genus **JASSONIRVANA** novum

Type, *Jassonirvana lineata* sp. nov.

Characters as given in the generic synopsis. Having somewhat the appearance of a small *Neocoelidea* of the Jassini, but indubitably a member of this family. Its appearance from above is not unlike that of a *Macroceratogonia.*

Jassonirvana lineata sp. nov. Plate 5, fig. 45.

Very pale ochraceous; two complete sublateral longitudinal orange bands on vertex are extended caudad to hind margin of pronotum; a broad median band on vertex, a broad median and two sublateral bands on pronotum ivory white, the latter extending caudad within claval suture to half the length of clavus; a broad orange band passes from base to apex of clavus next the commissure; corium and membrane subhyaline, the former slightly tinged with ochraceous. Length, female, 4.25 millimeters; male, 3.5.

Face (Plate 5, fig. 45, *c*) as broad as long, eyes very large; loræ long and very narrow; front broadly flattened except at base where it is strongly convex below apex of vertex; surface shagreened; median carina confined to apical half. Supra-antennal carina weak and strongly curved. Basal lateral areas of face roundly convex, entirely without frontal folds or wrinkles. Anterior margin of vertex entirely without bordering carina, the vertex being smoothly rounded on to face; ocelli on this rounded border a little within the lateral border of crown as seen from above and about three times their diameter from eye. Length of vertex (Plate 5, fig. 45, *a*) one and a half times interocular width, strongly narrowed between the deep-set eyes, the lateral margins of head in front of eyes straight for a short distance, then oblique to the obtuse-angulate apex; surface of vertex evenly gently convex, shagreened, sides and base without raised margins. Length of pronotum a fifth greater than length of vertex, anterolateral margins subequal to posterolateral and into width about four times; surface smooth with some faint indications of cross wrinkling on median basal area. Scutellum much shorter than pronotum, surface smooth. Several rows of coarse pit punctures on basal part of corium; clavus opaque; corium translucent, entire apical area hyaline; a transverse cross vein (Plate 5, fig. 45, *d*) near apex of subcostal area, and just before this an indication of a very oblique cross vein which joins the former at base; venation peculiar in that all the apical cells are strongly narrowed to base and all bordering on the radial

area; marginal vein outwardly at apex extraordinarily thickened; appendix well developed. Subgenital plate of female with hind margin deeply broadly incurved.

LUZON, Laguna Province, Los Baños and Mount Maquiling (*Baker*): Bataan Province, Mount Limay (*Baker*).

STENOMETOPIINÆ

Genus STENOMETOPIUS Matsumura

Matsumura, Journ. Coll. Agr. Sapporo 5 (1914) 217.

Type, *Stenometopius formosanus* Matsumura.

Head broadly laminately extended but thick dorsoventrally; vertex between three and four times as long as interocular width; eyes deeply set in vertex; posterior margin of pronotum nearly straight; sides of clypeus subparallel; pronotal lateral carinæ wanting; temples narrow; antennæ inserted close to and between eyes; tegmina with two subapical cells; ocelli beneath border of vertex and not visible from above.

Through *Pythonirvana* and *Jassonirvana,* the relationship of this genus to *Nirvana* is indicated. Whether or not *Stenometopiellus* Haupt[34] has any close relationship with *Stenometopius* I do not know. Of his genus Haupt described one species, *sigillatus,* from Buchara.

Synopsis of species.

a^1. Median area of tegmina shorter, length about five times width; first anteapical cell outside radius (as figured) very small, about half the length of second.. S. formosanus Matsumura.

a^2. Medial area of tegmina very long, length more than seven times the width; first anteapical two-thirds the length of second and directly following the radial area.. S. mindanaoensis sp. nov.

Stenometopius mindanaoensis sp. nov. Plate 5, figs. 46 and 47.

Sordid ochraceous, spotted and banded with brownish; two oblique bands across pleuræ and two oblique stripes on each ventral segment dark brownish; two small oblique stripes on sides of face, the lower part of front, and a curved stripe along its basal border pale brown. Vertex with two oblique pale brown stripes on either side of anterior half; a reddish stripe starts from the margin in front of eyes, curves caudad, passes near eye, and indistinctly crosses pronotum and basal angles of scutellum; median carina of vertex whitish anteriorly, brownish posteriorly. Tegmina translucent, the subcostal area,

[34] Wien. Ent. Zeit. 36 (1917) 251.

outer subapical cell, and fourth apical cell largely albescent with brownish margins; apical veins broadly white. Length of female, 5 millimeters.

Face (Plate 5, fig. 46, *c*) twice as long as broad; the basal lateral sutures of front beyond antennæ not distinct, the strong margins shown in the figure being not the sutures but the strongly marked limits in facial view of the lower concave shagreened portion of front, which basally is strongly narrowed into the laminately compressed basal portion, the sides of which are smooth. Antennæ inserted close to middle of eye margin, not in an excavated scrobe, and without a supra-antennal ledge or carina. Ocellus small, a little farther from border of vertex than from eye, and without wrinkles or carinæ in its vicinity. Vertex (Plate 5, fig. 46, *a*) three and three-fourths times as long as interocular width, broadly spatulate in outline, sides passing forward from outer line of eye, obtuse-angulate at apex; lateral areas gently depressed, basal two-thirds shagreened, apical one-third longitudinally wrinkled. Claval veins strong and prominent; venation as shown in Plate 5, fig. 47. Subgenital plate of female truncate.

MINDANAO, Davao Province, Davao: Bukidnon Province, Tangkulan (*Baker*). Described from Formosa and also found in Mindanao, representatives of this remarkable genus will doubtless also be found in the intervening islands.

ILLUSTRATIONS

Plate 1

FIG. 1. Hind tarsi of various Jassoidea. *a, Onukia muirii* sp. nov.; *b, Pythamus melichari* Baker var. *borneensis* var. nov.; *c, Stenometopius mindanaoensis* sp. nov.; *d, Preta luzonensis* sp. nov.; *e, Stenotortor inocarpi* sp. nov.; *f, Paropia scanica* Fall.

2. *Kyphocotis tessellata* Kirkaldy; *a*, tegmen; *b*, face; *c*, profile of head.

3. The face in *Koebelia, Ulopa*, and *Paropia*. *a, Koebelia californica* Baker, face; *b, Ulopa trivia* Germ., face, frontal view; *c, Ulopa trivia* Germ., face, lateral view; *d, Paropia scanica* Fall., face, frontal view; *e, Paropia scanica* Fall., face, lateral view.

4. *Signoretia maculata* sp. nov.; *a*, head and pronotum, dorsal view; *b*, head and pronotum, lateral view; *c*, face.

5. *Signoretia carinata* sp. nov.; *a*, head and pronotum, dorsal view; *b*, head and pronotum, lateral view; *c*, face.

6. *Signoretia bilineata* sp. nov.; *a*, head and pronotum, dorsal view; *b*, head and pronotum, lateral view; *c*, face.

7. *Signoretia benguetensis* sp. nov.; *a*, head and pronotum, dorsal view; *b*, head and pronotum, lateral view; *c*, face; *d*, tegmen.

8. *Preta gratiosa* Melichar; *a*, head and pronotum, dorsal view; *b*, head and pronotum, lateral view; *c*, face.

9. *Preta luzonensis* sp. nov.; *a*, head and pronotum, dorsal view; *b*, head and pronotum, lateral view; *c*, face.

10. *Euacanthus interruptus* Linnæus (Japan); *a*, head and thorax, dorsal view; *b*, head and pronotum, lateral view; *c*, face.

Plate 2

FIG. 11. *Pythamus productus* sp. nov.; *a*, head and pronotum, dorsal view; *b*, head and pronotum, side view; *c*, face.

12. *Pythamus decoratus* sp. nov.; *a*, head and pronotum, dorsal view; *b*, head and pronotum, lateral view; *c*, face.

13. *Pythamus melichari* Baker var. *bilobatus* var. nov.; *a*, head and pronotum, dorsal view; *b*, head and pronotum, lateral view; *c*, face.

14. *Pythamus melichari* Baker var. *singaporensis* var. nov.; *a*, head and pronotum, dorsal view; *b*, head and pronotum, lateral view; *c*, face.

15. *Pythamus melichari* Baker var. *borneensis* var. nov.; *a*, head and pronotum, dorsal view; *b*, head and pronotum, lateral view; *c*, face; *d*, tegmen.

16. *Onukia onukii* Matsumura; *a*, head and pronotum, dorsal view; *b*, head and pronotum, lateral view; *c*, face; *d*, tegmen.

FIG. 17. *Onukia corporaali* sp. nov.; *a*, head and pronotum, dorsal view; *b*, head, lateral view; *c*, face.

18. *Onukia muirii* sp. nov.; *a*, head and pronotum, dorsal view; *b*, head, lateral view; *c*, face; *d*, tegmen.
19. *Onukia kelloggii* sp. nov.; *a*, head and pronotum, dorsal view; *b*, head and pronotum, lateral view; *c*, face.
20. *Oniella leucocephala* Matsumura; *a*, head and pronotum, dorsal view; *b*, head, lateral view; *c*, face; *d*, tegmen.

PLATE 3

FIG. 21. *Balbillus albellus* sp. nov.; *a*, head and pronotum, dorsal view; *b*, head and pronotum, lateral view; *c*, face; *d*, tegmen.

22. *Stenotortor inocarpi* sp. nov.; *a*, head and pronotum, dorsal view; *b*, head and pronotum, lateral view; *c*, face.
23. *Stenotortor inocarpi* sp. nov. Tegmen.
24. *Kana illaborata* Distant; *a*, head and pronotum, dorsal view; *b*, head and pronotum, lateral view; *c*, face.
25. *Kana illaborata* Distant; *a*, tegmen; *b*, wing.
26. *Kana picea* sp nov.; *a*, head and pronotum, dorsal view; *b*, head and pronotum, lateral view; *c*, face; *d*, tegmen.
27. *Kana maculata* sp. nov.; *a*, head and pronotum, dorsal view; *b*, tegmen.
28. *Kana anomala* sp. nov.; *a*, head and pronotum, dorsal view; *b*, tegmen.

PLATE 4

FIG. 29. *Nirvana placida* Stål, female; *a*, head and pronotum, dorsal view; *b*, head and pronotum, lateral view; *c*, face; *d*, tegmen.

30. *Nirvana placida* Stål, male; *a*, head and pronotum, dorsal view; *b*, tegmen.
31. *Nirvana philippinensis* sp. nov., male; *a*, head and pronotum, dorsal view; *b*, tegmen.
32. *Pseudonirvana ocellaris* sp. nov.; *a*, head and pronotum, dorsal view; *b*, tegmen.
33. *Pseudonirvana penangensis* sp. nov.; *a*, head and pronotum, dorsal view; *b*, tegmen.
34. *Pseudonirvana singaporensis* sp. nov.; *a*, head and pronotum, dorsal view; *b*, tegmen.
35. *Pseudonirvana malayana* sp. nov.; *a*, head and pronotum; *b*, tegmen of male.
36. *Pseudonirvana sandakanensis* sp. nov.; *a*, head and pronotum, dorsal view; *b*, tegmen.
37. *Pseudonirvana davaoensis* sp. nov.; *a*, head and pronotum, dorsal view; *b*, face, lateral view; *c*, tegmen.
38. *Pseudonirvana sanguineolineata* sp. nov.; *a*, head and pronotum, dorsal view; *b*, tegmen.
39. *Pseudonirvana longitudinalis* Distant; *a*, head and pronotum, dorsal view; *b*, tegmen.

PLATE 5

FIG. 40. *Ophiuchus basilanus* sp. nov.; *a*, head and pronotum, dorsal view; *b*, head and pronotum, lateral view; *c*, tegmen.

41. *Ophiuchus montanus* sp. nov.; *a*, head and pronotum, dorsal view; *b*, head, lateral view.

42. *Ophiuchus marginatus* sp. nov.; *a*, head and pronotum, dorsal view; *b*, head, lateral view; *c*, tegmen.

43. *Nirvanoides amboinensis* sp. nov.; *a*, head and pronotum, dorsal view; *b*, head and pronotum, lateral view; *c*, tegmen of male; *d*, tegmen of female.

44. *Pythonirvana muiri* sp. nov.; *a*, head and pronotum, dorsal view; *b*, head and pronotum, lateral view; *c*, face; *d*, tegmen.

45. *Jassonirvana lineata* sp. nov.; *a*, head and pronotum, dorsal view; *b*, head and pronotum, lateral view; *c*, face; *d*, tegmen.

46. *Stenometopius mindanaoensis* sp. nov.; *a*, head and pronotum, dorsal view; *b*, head and pronotum, lateral view; *c*, face.

47. *Stenometopius mindanaoensis* sp. nov.; tegmen.

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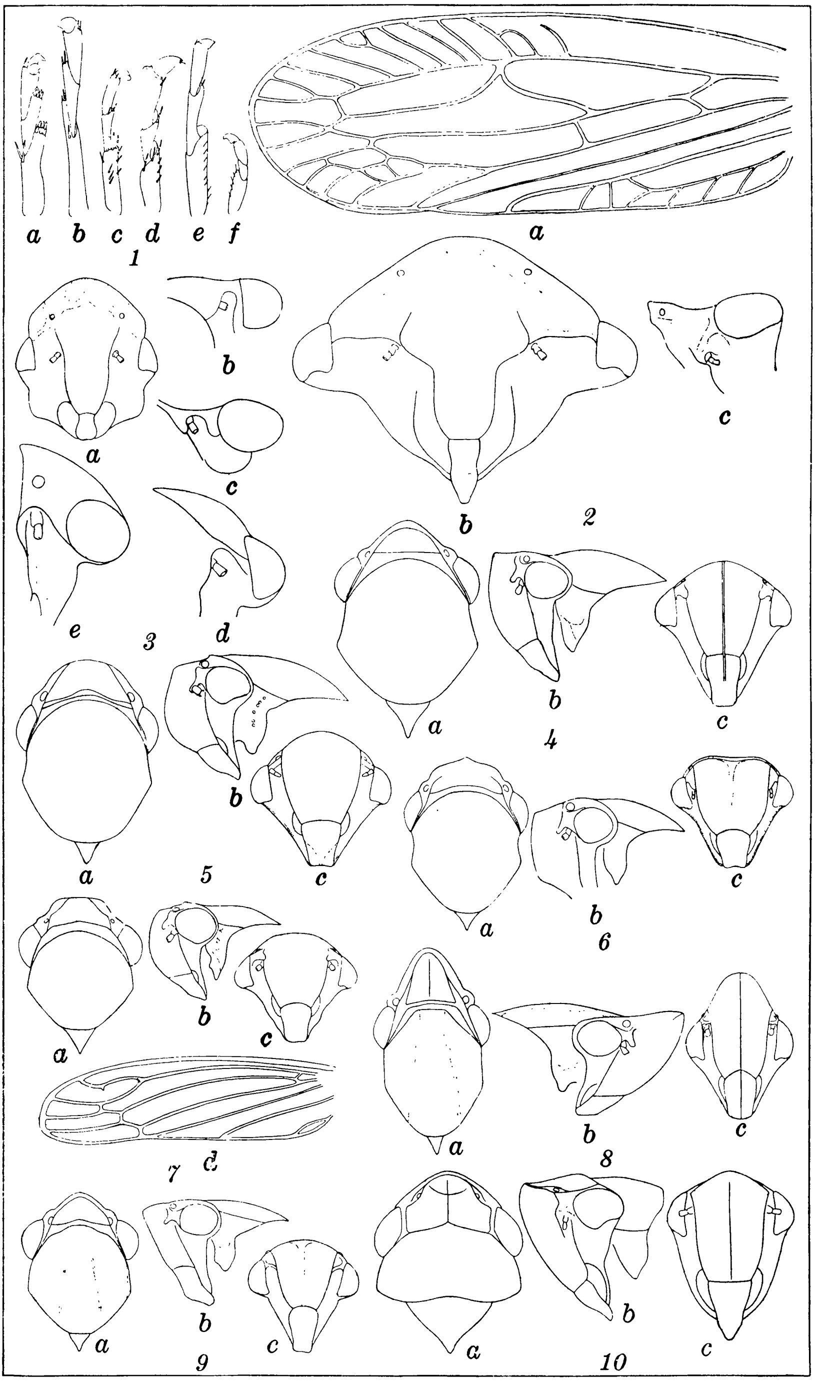
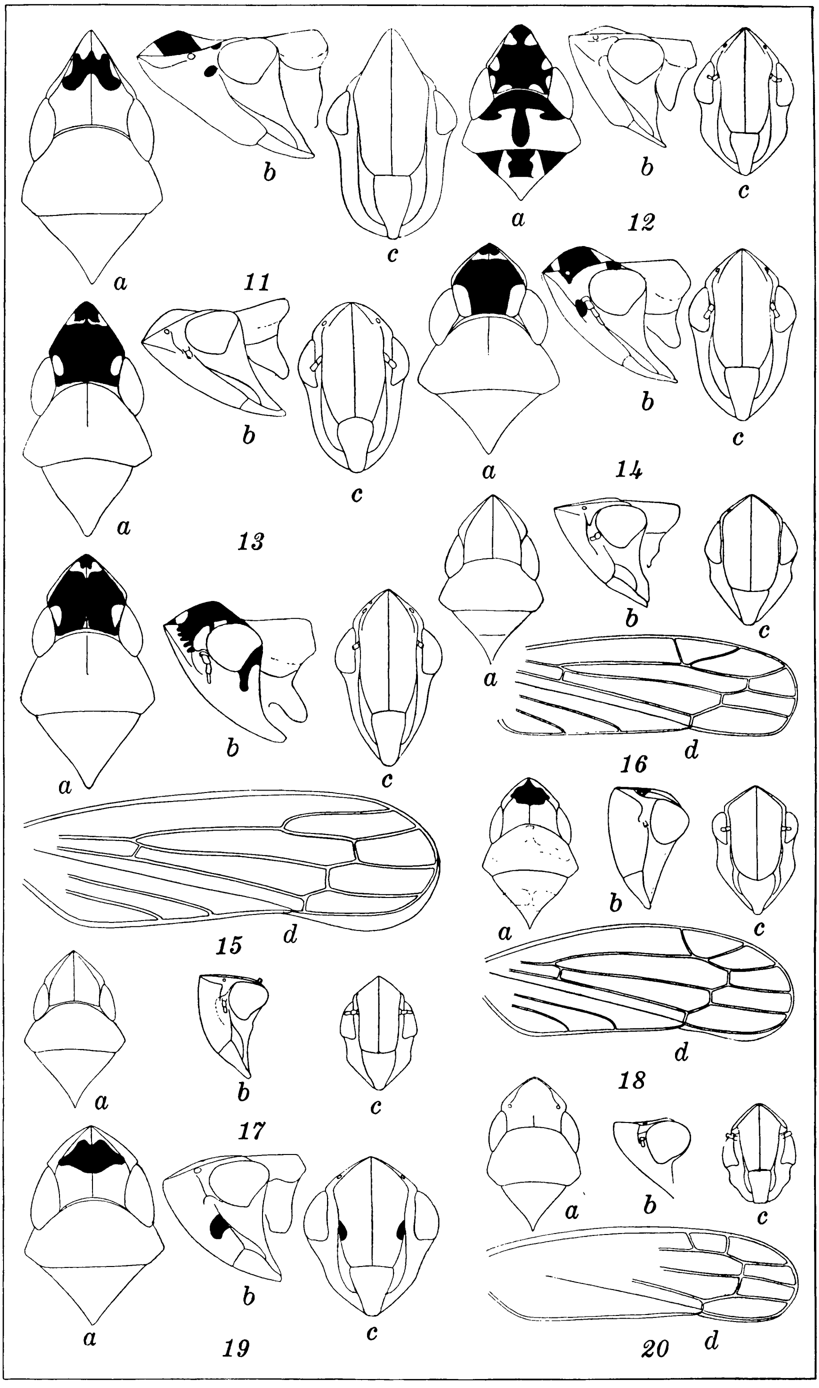


PLATE 1.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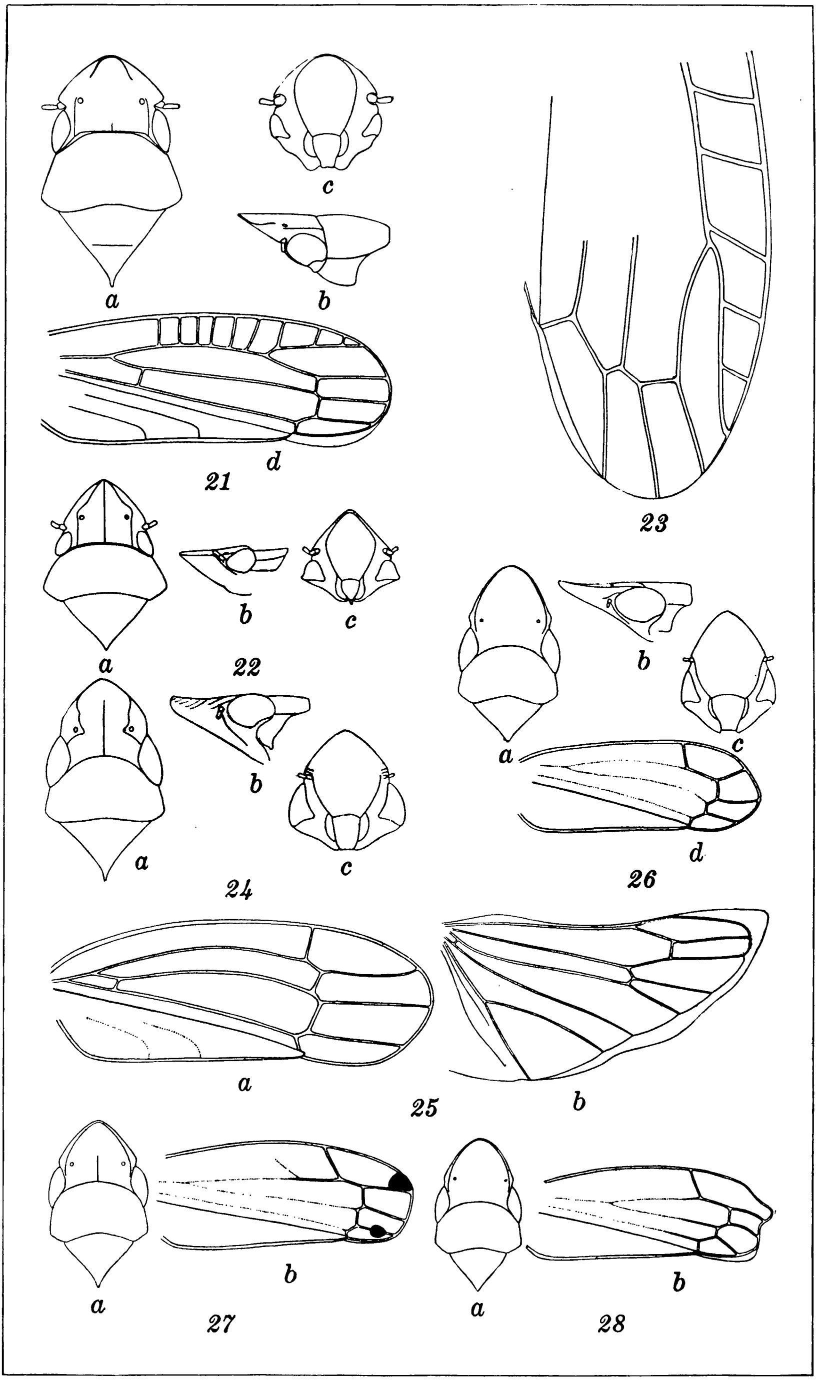

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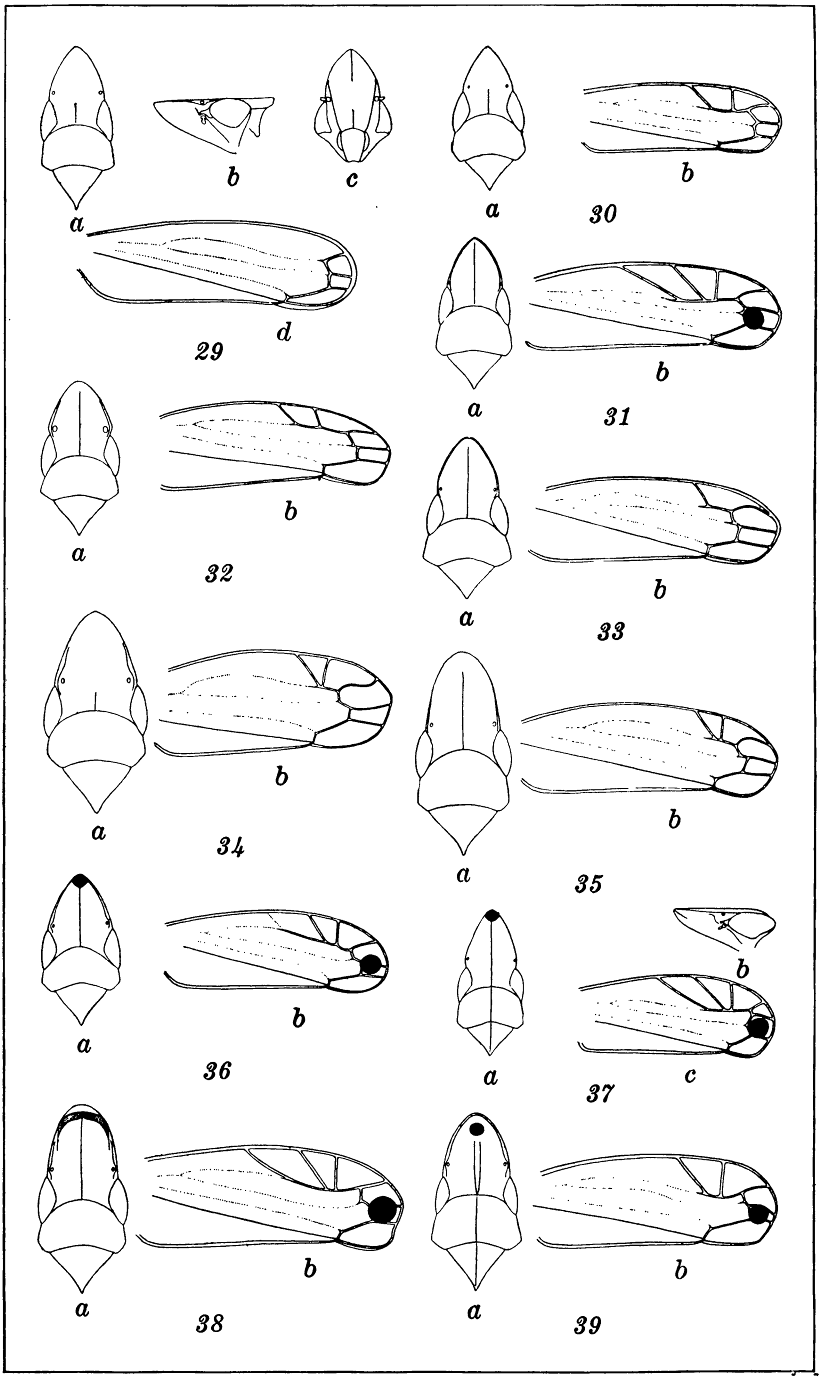

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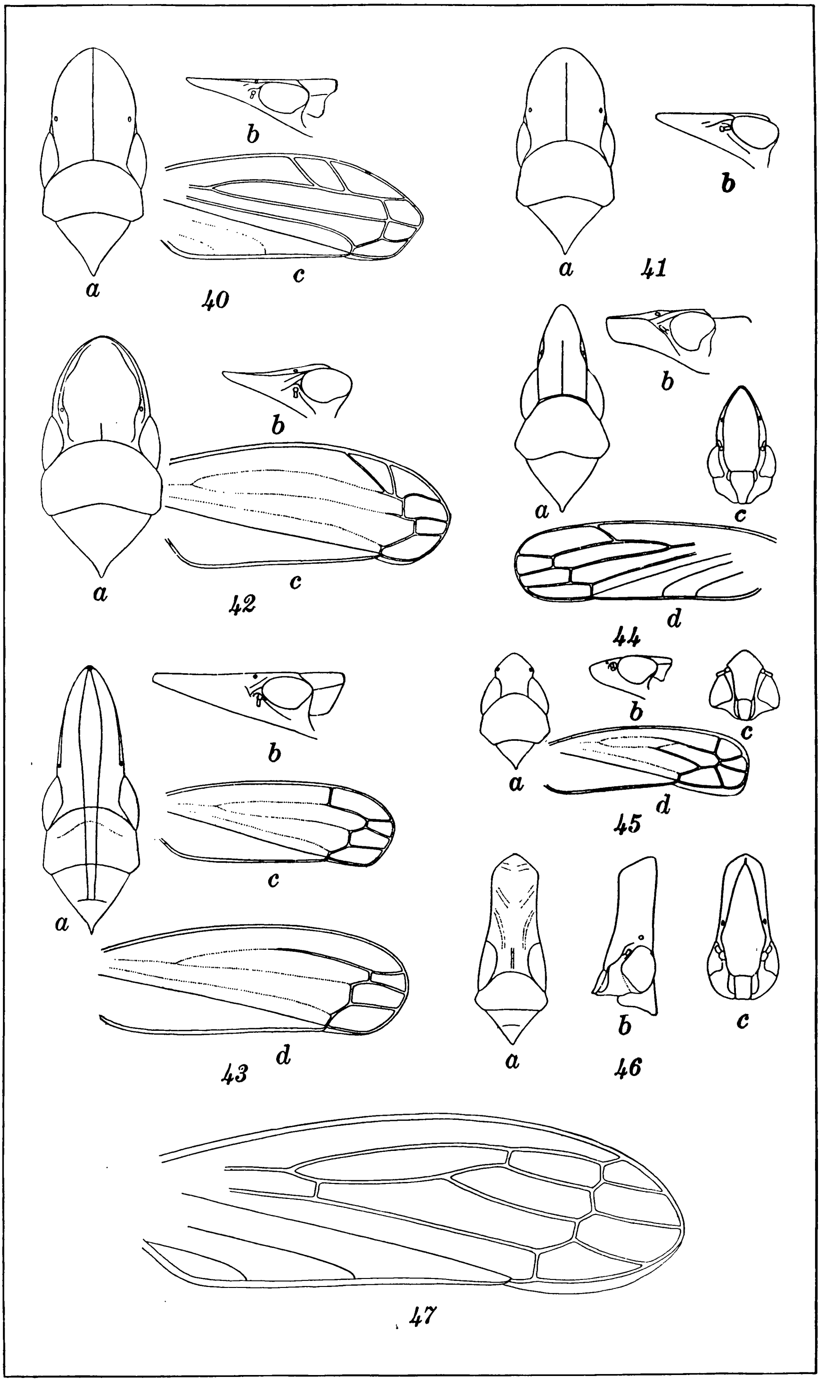

PLATE 5.

VOL. 23, NO. 5 NOVEMBER, 1923

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THE PHILIPPINE JOURNAL OF SCIENCE

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METABOLIC MECHANISM IN BERIBERI [1]

By WM. D. FLEMING

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The bulk of the work, other than purely clinical, published on beriberi has dealt largely with anatomical findings, gross or microscopical. On functional disturbances one finds a meager literature, reporting results often widely varying, and conclusions from these results in many cases radically opposed. De Langen and Schut(5) found evidence of a lowering of blood lipoids. Jansen and Mangkoewinoto,(9) investigating the respiratory quotient of birds fed upon polished rice until polyneuritis developed, found an occasional fall in the respiratory quotient but this fall was not constant and could not be accepted as a criterion of the condition. Anderson and Kulp(1) found no change in the respiratory quotient of chickens in vitamine B starvation. This is corroborated by work recently reported by Mattill(10) indicating that deprivation of vitamine B does not interfere with glucose combustion. Hopkins(8) and Renshaw(12) found that vitamines apparently aided the use of sources of energy in metabolism.

The opportunity has recently been afforded the writer of examining the question of the respiratory metabolism in human subjects suffering from beriberi. An investigation of this disease as it occurred in the wards of the Philippine General Hospital, Manila, was undertaken by a committee of the staff

[1] From the laboratory of the United States Army Medical Department Research Board, Bureau of Science, Manila, P. I. Received for publication April 19, 1923.

of the Philippine General Hospital operating with the United States Army Medical Department Research Board. The patients examined were those in whom the diagnosis of beriberi had been made by this committee as a whole. The work done consisted in the determination of the basal metabolic rate, the urinary nitrogen, the respiratory quotient both for total combustion and for nonprotein combustion, and the fraction of the total heat derived from protein, fat, and carbohydrate, respectively. For these determinations the technic of Boothby and Sandiford(4) was followed, with estimation of nitrogen by the Folin micro-Kjeldahl method. In addition, determinations of blood sugar, nonprotein nitrogen, urea nitrogen, and creatinine were made by the system of Folin and Wu,(7) and of uric acid by the new method of Benedict.(3)

The data obtained are negative as pertaining to a definite pathological process in beriberi. However, the negative evidence is of interest as showing a metabolism essentially normal in a disease in which dietary factors loom so large. These factors are chiefly two: the lack of an essential element, the vitamine; and a very high carbohydrate content of the diet. Without discussing the question of how far vitamine deficiency can be considered an active factor in beriberi or taking up the question of infection as a causative agent, either direct or indirect in connection with the vitamine, two points may be noted. The first is that, unlike the experimental animals studied by Jansen and Mangkoewinoto, by Anderson and Kulp, and by Mattill, which were kept under a known vitamine deficiency, the patients studied in the present work, while in hospital, were kept on a diet rich in sources of vitamine B. The clinical symptoms of a polyneuritis may have been the residual result of a previous vitamine deficiency, this residuum being slow of regeneration, while the patients were, at the time studied, restored to a normal metabolism by the diet used in treatment. This possibility is realized. Against it the results of the work on animals by the investigators named must be cited.

Aub(2) and others have shown that the secretion of the suprarenal glands has a marked influence on the metabolic rate, raising this rate independently of action of the thyroid. This action, while appearing more quickly than that of the thyroid, is not so lasting. Since McCarrison(11) found hypertrophy of the suprarenals a prominent feature of beriberi, some expectation of an increased basal metabolic rate in these

beriberi patients was held. However, no evidence was found of any disturbance of metabolism as characteristic of beriberi, either in the level on which the metabolism was maintained or in the relative value of the sources of this metabolism. This absence of any shift in the usual proportion in which the respective sources of energy are utilized is interesting in the face of the high carbohydrate intake.

Table 1 gives the metabolism data for the beriberi patients and for a series of normal controls, the latter being convalescents in the surgical wards showing no symptoms of beriberi or of other conditions known to affect metabolism.

TABLE 1.—*Results of metabolism determinations.*

	Beriberi patients.	Surgical convalescents.
Basal metabolic rate .... per cent..	—6.3	—5.3
Respiratory quotient	0.823	0.854
Nonprotein respiratory quotient	0.832	0.886
Total calories per hour	48.84	56.51
Calories from protein	10.39	11.59
Percentage of total calories from protein	19.2	20.8
Calories from fat	24.91	17.66
Percentage of total calories from fat	46.7	31.2
Calories from carbohydrate	18.59	26.77
Percentage of total calories from carbohydrate	34.1	48.1

Comparison of the results for these two groups brings out the following facts:

1. There is no significant difference in the basal metabolic rates of the two groups.

2. There is no significant difference in the respiratory quotients. Both quotients are indicative of a normal utilization of the food eaten.

3. In the percentages of the heat derived from the combustion of protein, fat, and carbohydrate, respectively, some differences are seen between the two groups. However, it is thought that these are variations between small groups rather than representatives of the particular group. Findlay(6) reported a reduction of glyoxalase in the liver of pigeons suffering from beriberi. While the percentage of heat derived from carbohydrate is less in the beriberi patients than in the normals it is still well within the limits of a normal metabolism and certainly cannot be taken as showing a definite breakdown in carbohydrate metabolism. Neither can any definite evidence be

found in this series of an abnormal utilization of protein or of fat.

In Table 2 are given the values found in the blood analyses of the two groups.

TABLE 2.—*Blood analyses.*

[All values are in milligrams per 100 cubic centimeters of blood.]

Group.	Cases.	Analyses.	Sugar.	Non-protein nitrogen.	Uric acid.	Urea nitrogen.	Urea.	Creatinine.
Beriberi with œdema	7	9	102	30.5	3.5	13.5	29.1	1.4
Beriberi without œdema	17	23	106	30.4	3.9	12.7	27.4	1.4
All beriberi cases	24	32	105	30.5	3.8	12.8	27.6	1.4
Normals	8	8	109	29.3	4.1	10.5	22.8	1.4

From the metabolic side two of these values, the blood sugar and the creatinine, are of especial interest. The blood sugar values confirm the evidence, discussed above, of a normal utilization of carbohydrate. Aside from the question of beriberi this is of interest as evidence against a diet high in carbohydrate, in itself predisposing to abnormalities of carbohydrate metabolism. It may be that the low total caloric value of the diet usual to the poorer Filipinos may be a factor of safety in this. Various workers have offered evidence that the full diet of the Jewish race in America is a factor in the high incidence of diabetes among that people. Here it must be remembered that the diet of the Jew is high in total caloric value rather than showing a decided preponderance of carbohydrate with a low total caloric value as obtains with the Filipino.

Viewing the creatinine values as an index of the endogenous metabolism, we find no difference between the two groups and a level in both slightly below that found in normal Americans, which is consistent with the minus basal metabolic rate found.

From the standpoint of damage to the excretory system in beriberi the blood analyses are valuable negative evidence, especially when the occurrence of œdema in this disease is remembered. Œdema was present in about one-third of the patients examined, but no differences were found referable to this symptom. In view of the actual presence of œdema in at least some of these patients when investigated, it is thought that the objection mentioned in the discussion of the metabolism, that the patients were then on a vitamine-rich diet, cannot apply here. The change of diet was of too recent institution to effect a recovery from any but slight and transitory damage

to the kidney. Nothing was found in the way of the marked increase in blood urea found by Yosikawa, Yano, and Nemoto (13) in some severe cases of beriberi.

SUMMARY

1. In a series of beriberi patients the basal metabolic rate was found to be the same as in normal controls. The respiratory quotients were normal. With the percentages of heat obtained from the combustion of protein, of fat, and of carbohydrate they point to a normal utilization of the food eaten. No evidence of the high carbohydrate intake as a disturbing factor was found.

2. Blood sugar values were against the high carbohydrate intake causing a "diabetic tendency."

3. No evidence was found of damage to the excretory power of the kidney in beriberi, either in patients with œdema or in those without this symptom.

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THE DEVELOPMENT OF BAGUIO PLATEAU

A STUDY IN HISTORICAL GEOLOGY AND PHYSIOGRAPHY IN THE TROPICS

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TWELVE PLATES AND SIX TEXT FIGURES

CONTENTS

INTRODUCTION

After several years spent in the study of Tertiary problems in the temperate regions of the Pacific Coast states of the United States, the writer has been much impressed with the differences in geologic and biologic processes of the Tropics as compared with similar processes in the temperate regions. Many times, during field work in the Philippines in the last three years, suggestions of these great differences were obtained in many connections. The exceedingly heavy rainfall over portions of the Archipelago and observations on results of these torrential

downpours[1] cause one to project these effects into the geologic past. In December, 1921, Mr. H. P. Whitmarsh, former governor of Benguet Subprovince, conducted Dr. W. D. Smith, Mr. G. B. Moody, and the writer to an interesting locality west of Baguio where an excellent and characteristic fauna of Vigo-Miocene age was obtained. Governor Whitmarsh had previously sent to the writer some excellent specimens of *Vicarya callosa* Jenkins, the finger post of the Miocene of the East Indian Archipelago, from one of these localities. With this evidence in hand an excellent geologic "datum plane of reference" was established in this region, and further data were secured which gave fairly definite evidence that Baguio Plateau had been developed by the wearing down of mountain systems, probably formed at the close of the Pliocene, to a gently rolling subdued topography which, in terms of Davis's geographic cycles, would be described as being of early old age. Not only was this surface apparently developed during the Pleistocene, but also it was hoisted to its present position, 1,250 to 1,500 meters (4,000 to 5,000 feet) above sea level during middle or late Pleistocene, faulted, and over much of the area of north-central Luzon eroded so completely that there are now but few isolated remnants of this once extensive low-lying country, which probably covered the central portion of northern Luzon during early Pleistocene. The deep erosion of Bued Cañon, Antamok Valley, and a large part of Agno River Gorge apparently has taken place during late Pleistocene and Recent times (Plates 1 and 2).

A great annual rainfall, alone, is not sufficient to cause this enormous erosion and the vast acceleration of geologic processes in this interesting locality; but the great rainfall delivered as torrential downpour, of intensity unknown in temperate regions, must be an important factor. This opinion is based upon observation in western Washington in the vicinity of the Olympic Mountains, the region of greatest rainfall in continental United States. This rainfall, however, while extremely large, is distributed over a considerable period of time, and a part of the precipitation during this time is not exceedingly heavy. The results are that the western slopes of the Olympic Mountains are covered with heavy forests of spruce, pine, hemlock, and cypress, with an exceedingly heavy undergrowth of tough shrubs with well-developed root systems. These root

[1] Annual average rainfall at Baguio, 4,598 millimeters.

systems are so extensive that the soil is firmly held in a perfect root mat, and erosion is consequently far less than one might think from a mere study of the amount of rainfall. Certain fair-sized streams in the coastal-plain region just north of Grays Harbor Bay have succeeded in digging only shallow valleys in the marine sediments of Pleistocene age, and but few of these streams have succeeded in trenching through the sands and gravels of this time to the underlying rocks.

From his previous experience the writer was quite unprepared to expect the conditions discovered in the vicinity of Baguio. The resemblance of the effects of tropical torrential downpour to that of arid and semiarid regions is noteworthy. The vast amount of débris deposited by such streams as the Agno and Bued as they debouch upon the central plain of Luzon is, after severe typhoons which swept across this region, reminiscent of cloud-burst effects in the Mohave Desert region of southern California. The writer hesitates to introduce a new variant into Davis's humid cycle, but the evidence compels him to conclude that quantity of rainfall is not sufficient to accelerate rapid development of topographic forms in humid tropical regions, but that the torrential character of great rainfall is the principal factor.

These general studies made in the environment of Baguio indicate that Luzon was visited by the same type of disastrous typhoons during Pleistocene age as continue to sweep across these islands at the present date.

REVIEW OF PREVIOUS WORK

Von Drasche [2] first made known the widespread occurrence of coralline limestone which is typically exposed at Trinidad, and he described the other rocks stratigraphically beneath this interesting formation.

> A short distance behind Kayan mighty breccias of doleritic rocks are encountered, then breccias of hornblende-sanidine trachyte, and farther eastward there appears a breccia-like rock bedded in thick layers [fig. 1]. The last-named consists of large and small irregular fragments of limestone and of a badly weathered trachytic rock. * * * This conglomerate alternates with strata of coralline limestone, very similar in every respect to that found in Benguet Province. The strata show an inclination to the southeast of 8°–12°.

Again he mentions this formation near Sagada.

[2] Von Drasche, R., Fragmente zu einer Geologie der Insel Luzon, Wien (1878) 36–46.

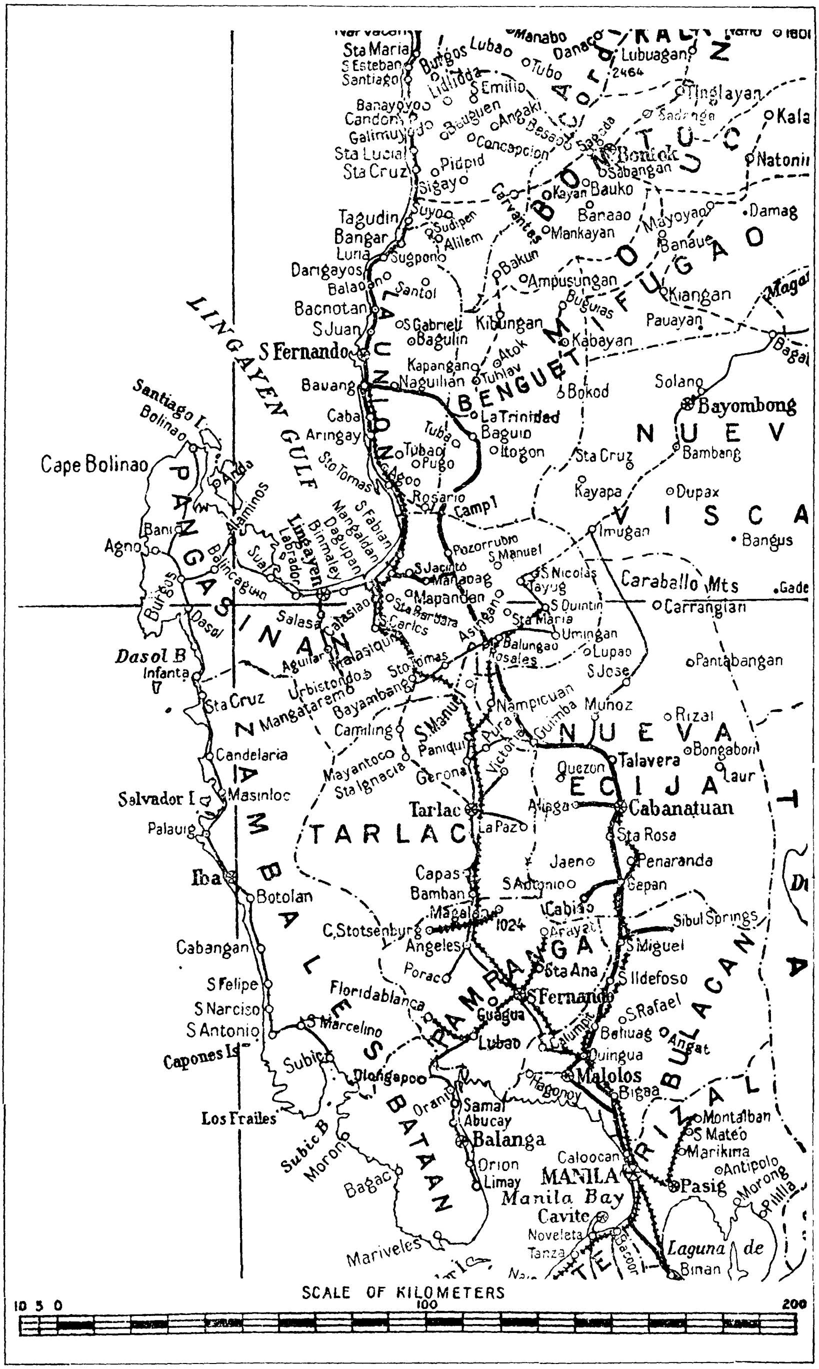

FIG. 1. Sketch map showing Baguio and a portion of central Luzon.

At Sagada extensive coralline limestone cliffs are again encountered. These may be traced south almost to Balugan and toward the north to Tetanan. * * * These coral reefs likewise show stratification with clearly discernible thick beds, usually with a southerly inclination of 15°–20°; between the strata I found a thin layer of greenish tuff.

He also mentions coralline limestone and tuff as an extensive mantling formation occurring in the vicinity of Lidlidda. Von Drasche discusses the age of this limestone as follows:

There can be no doubt that the coralline limestones belong to the most recent rocks occurring in northern Luzon. They always form the uppermost member of all formations, and with the exception of Benguet, where they are covered with a thin layer of red earth, I failed to find these limestones beneath other rocks.[8] * * * Even though it was impossible to give a reliable specific report on account of the poor state of preservation of the fossils, it nevertheless was possible for us [von Drasche and von Marenzeller] to declare with certainty that with the exception of one single piece which we could not identify, all of the rest belonged to genera which occur today in great abundance in the Indian Ocean, and even the individual corals can be referred without any question to living types. The corals examined do not show the least relationship to the Tertiary corals from Java described by Reuss.

Regarded from this point of view, the raised coral reefs of Luzon must be considered as very recent in origin. The genera identified by us are the following: *Galaxaea*, sp., *Favia*, sp., *Maendrina*, sp., *Porites* 2 sp. (?), *Astraeopora*, sp.

Von Drasche advances the view that Trinidad Valley represents a coral atoll. This hypothesis will be discussed later. The sequence of rocks established by von Drasche was—

(1) The coral reefs and breccias of coralline limestone with recent volcanic rocks; (2) the tuffs and tuff sandstones associated at places with coralline limestone beds and marls with plant remains; (3) recent eruptive rocks (quartz trachyte, sanidine hornblende-trachyte, hornblende-andesite, and dolerite); (4) the Agno beds, a mighty system of coarse sandstones and conglomerates which have been derived from the underlying diabase and aphanitic rocks; and (5) diorite, protogine gneiss, and chlorite schist.

A part of von Drasche's second group, as will be shown later, is the Vigo group unconformably beneath the coralline limestone and contains a coral fauna like the one described by Reuss from the Tertiary of Java. However, let this not be regarded as a carping criticism of the work of this hardy geological pioneer who first made known this interesting upland, and who amid privations of numerous kinds could still see

[8] This statement by von Drasche is modified by our present knowledge. The Baguio formation rests unconformably upon these Pliocene limestones.—R. E. D.

visions of the past through the well-trained eyes of the expert scientist.

The next worker in this field was A. J. Eveland, who contributed an excellent article upon the geology and mineral prospects in the Baguio region. Eveland published with this report a good reconnaissance map of the Benguet mineral regions, upon which are outlined the various geologic formations. Eveland recognized the peneplain character of Baguio Plateau and gives an excellent description of it. He says in part:[4]

> The Baguio Plateau is the most striking of the four physiographic types of the region. It is a peneplain of limited extent, with an average elevation of about 5,000 feet and with a drainage and topography so characteristic of a lowland region, that, viewed from a central point where the valleys of the Bued and Agno River drainage are not visible, it is hard to realize the situation of the area.

Eveland also recognized that Mount Santo Tomas was a block mountain upthrust above the plateau by movements along a fault bounding this mass on the northeast. In the same publication Smith discusses the petrography of the rocks of this region.[5]

Four years later Smith and Eddingfield[6] presented a revised map of the Baguio region, revised the geologic scale, and gave additional notes upon the economic geology of the region.

GEOLOGY

GENERAL STATEMENT

The oldest rocks exposed in the vicinity of Baguio occur in Antamok Valley (Plate 2). These rocks represent a portion of the basement complex of schists, diorites, slates, and cherts which form the backbone of most of the larger islands of the Philippine Archipelago. In Antamok Valley the basement complex is represented by a characteristic plutonic rock, a diorite. This diorite is technically described by Smith.[7] It seems possible that this diorite is intrusive in the slates and cherts of probable Jurassic age.

The next oldest rocks are the conglomerates, sandstones, and carbonaceous shales of Miocene age, and they are best seen in

[4] Philip. Journ. Sci. § A 2 (1907) 219.

[5] Smith, W. D., Petrography of some rocks from Benguet Province, Luzon, P. I., Philip. Journ. Sci. § A 2 (1907) 235.

[6] Smith, W. D., and Eddingfield, F. T., Additional notes on the economic geology of the Baguio mineral district, Philip. Journ. Sci. § A 6 (1911) 429.

[7] Philip. Journ. Sci. § A 2 (1907) 235.

the region about 6 kilometers west of Baguio, where they have yielded a typical Vigo fauna.

Two kilometers east of this place coralline limestones and conglomerates rest with probable unconformity upon the strata of Vigo age and upon andesite intrusive in the Vigo. These limestones upon the basis of their fauna have been correlated with the Malumbang formation, whose type locality is in Bondoc Peninsula, Tayabas Province, Luzon. Since their deposition they have been elevated, folded, and faulted.

Resting unconformably upon marly limestone phases of the Malumbang formation are the tuffs and breccias of the Baguio formation, which have been considerably faulted and folded. Across these various rocks, through the process of erosion in a tropical region, a low-lying plain dotted with well-rounded, low mountains was developed over the present site of central Luzon, and the streams of the early Pleistocene wandered indifferently across the folded and faulted tuffs and breccias of the Baguio formation, as well as the folded Malumbang limestones and Vigo sandstones and shales (Plate 3). The last condition is well illustrated by Trinidad River, which was developed upon this plain and is now well intrenched in the vicinity of Trinidad. After the development of this surface, the whole region was elevated. The elevation was accompanied by some faulting, and movements along these lines of weakness have continued to the present time. The faulting is well shown by the raising of such great masses as Santo Tomas above the general level of the plateau. The faulting aided the enormous erosion of the typhoon season which has almost completely swept away the old Pleistocene surface from vast areas, leaving a region that is now at the typical stage of early maturity. Only the Baguio remnant exists in the near vicinity, but farther northeast, at Sagada, a similar plateau is reported, and a small residual is found at Pauai (Haight's place), 54 kilometers north of Baguio, and at Mount Data. Dr. W. D. Smith, who recently visited this noted mountain, describes it, in litt., as follows:

Mount Data.—Mount Data is a high block mountain (altitude, 2,650 meters, or 8,000 feet) made up almost entirely of beds of tuff and andesite agglomerate more or less in a horizontal position standing out very prominently in the landscape, marked on at least three sides by very imposing fault scarps. The topographic unconformity between this physiographic unit and that of the surrounding country is even more marked than in the case of the Baguio Plateau. The mountain has never been accurately mapped nor even roughly outlined. The accompanying diagram is an attempt to indicate its general shape and topography as sketched

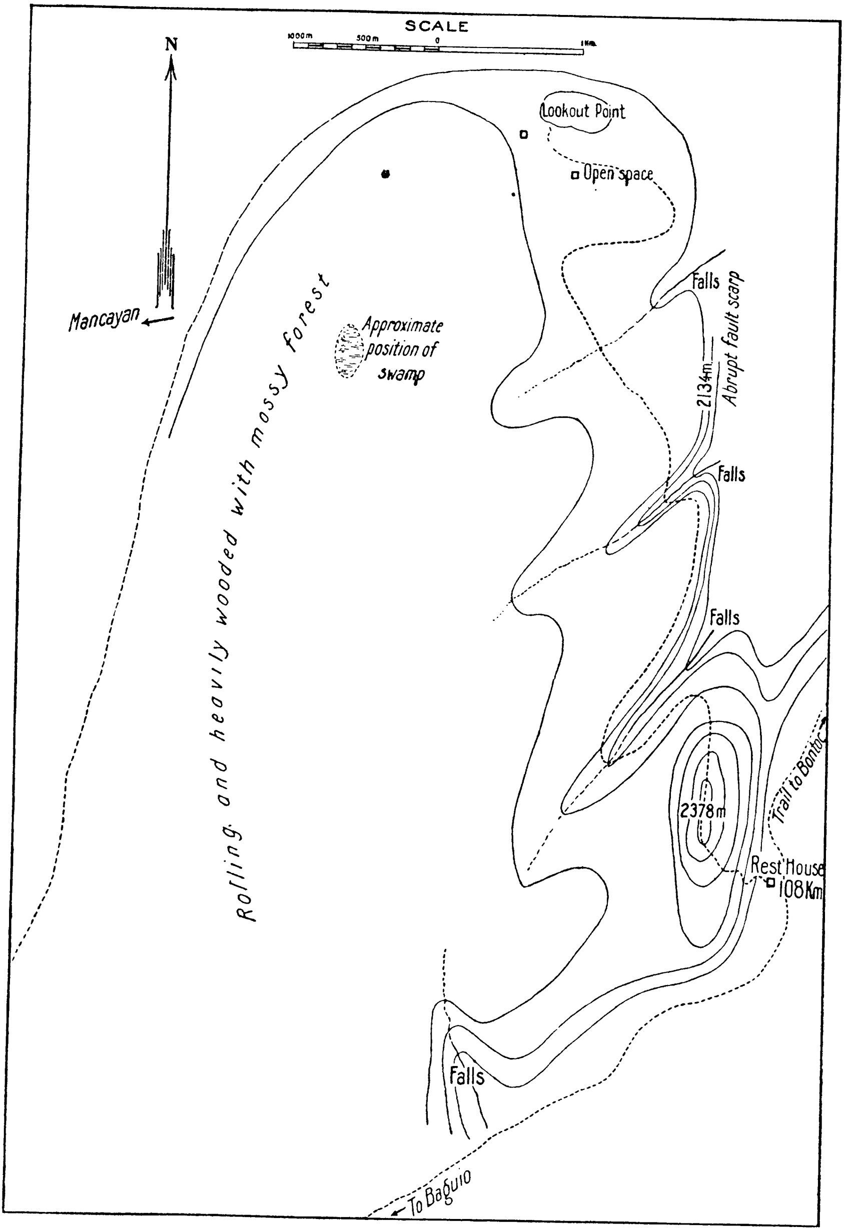

FIG. 2. Sketch map of Mount Data, Mountain Province, Luzon.

from the high point immediately back of the rest house at kilometer 108 (text fig. 2). The eastern escarpment is very imposing (Plate 4, fig. 1). It is at least 1,500 feet (450 meters) in height, with an average slope of about 60°. Over the side of this eastern wall plunge several considerable streams of water in wonderful cascades. One of these takes a total drop

of 500 meters in four or five plunges. In some places the walls are perpendicular. The surface of this plateau is very much like that at Haight's, Pauai, near kilometer 57, but owing to the heavy timber of the mossy-forest type it is difficult to make out the exact configuration of the surface (Plate 4). There is a fairly level area on the summit and in places in the rainy season standing water is to be noted and there is more or less swampy ground there. This has given rise to the tradition of a lake on top of Mount Data. At the time of my visit at the beginning of the rainy season I saw nothing which I could call a lake. Another point which has been exaggerated with reference to this mountain is the limestone on it. The only limestone that I saw on or about the mountain was a small residual patch of badly weathered limestone (Malumbang?) on the southeast slope very close to the Bontoc trail at an elevation of approximately 2,040 meters (6,800 feet).

At the extreme north end of this plateau there is a high rock from which the best panorama I have ever had in the Philippines is obtained. This rock is made up of agglomerate with a considerable amount of water-worn bowlders firmly cemented in an andesite matrix. There is no question in my mind that Mount Data is to be correlated with the Baguio Plateau.

Kilometer 81.—At about kilometer 81 on the Baguio north trail and 0.5 kilometer to the east of the trail there is a small plateau remnant with a remarkable "hanging valley" as shown in the accompanying photograph (Plate 4). The topography of this plateau remnant is distinctly old age or at least very mature, and at the south end there are a precipitous cliff and a large slide. In the upper portion of this slide there is an excellent section which shows one interesting feature; namely, an old buried soil about 1.5 meters thick, which at a distance has the appearance of a coal seam. A sample of this was obtained and proved to be merely a heavy deposit of humus. It is not even peat. There is about a meter of sand and tuff above this with the present soil on top.

Mancayan.—As you have suggested that the Mancayan region as shown on the old Bureau of Mines topographic map might also be a remnant of this old plateau, I studied it again, and I am in doubt about it. My opinion is that the Mancayan Plateau is not to be correlated with these other plateau remnants for the following reason: It seems to be an isolated topographic feature due to exceptionally hard quartz material, a part of which is covered by a trachyte flow. Its topography seems to me to be quite different from that of the other plateaus.

Sagada.—It has been suggested by some that Sagada is another plateau remnant. I have not visited this region since we have discussed this particular feature, but from my recollection of that country I am of the opinion that it does not correspond to the areas we have been discussing. There is a considerable bench near the Sagada Mission which is due to subsidence. However, there may be other areas in the vicinity of Sagada which I did not see.

River terraces.—As one travels north on the Baguio-Bontoc Trail particularly in looking across Agno Valley to the east several well-defined river terraces and elevated benches, at present far from the river, high on the sides of the Polis Range are distinctly visible. These undoubtedly are to be correlated with such terraces and benches as we have noted in Bued River Cañon near the Kias Trail and in the country to the northwest of Trinidad.

DIORITE

The best exposures of diorite in the Baguio region occur in Antamok Valley and vicinity (Plates 1 and 2). Iddings,[8] in describing a sample from Antamok Valley, says:

> At Antamok, Benguet Province, there is medium-grained quartz-diorite, with inequigranular consertal fabric. It consists of plagioclase and considerable brownish-green hornblende, anhedral with respect to each other, but euhedral toward quartz and orthoclase. There is some altered biotite. In places the orthoclase is intersertal to poikilitic, with inclusions of plagioclase and hornblende.

Diorites frequently associated with schists commonly compose a part of the basement complex upon which sedimentary rocks of the Vigo group of Miocene age were deposited. In many places fragments of diorite compose the sandstone of Vigo age and occasionally the sandstones are decidedly arkosic. The abundance of feldspar, hornblende, and quartz grains in the Vigo sandstones is in sharp contrast with their absence or rare occurrence in the sandstones of Malumbang Pliocene age.

VIGO GROUP, MIOCENE AND INTRUSIVES IN THE VIGO GROUP

Six kilometers west of Baguio City Hall and 400 meters south of the Naguilian Road at an elevation of 1,095 meters (3,650 feet, aneroid) a dark gray, argillaceous sandstone which weathers to a tan clayey sandstone occurs (Plate 2). Embedded in this sandstone are numerous specimens of *Vicarya callosa* Jenkins and coral fragments. The strike is approximately east and west, with a dip of 35° south. These sandstones without much doubt are unconformably below the Malumbang formation, as the dip is greater and the strike observations taken in the Vigo of this vicinity indicate that the Vigo group was faulted and folded along different axes than the gently inclined, westerly dipping limestones exposed along the Naguilian Road between kilometer posts 4 and 5. In this vicinity the dip in the coralline limestone, as Plate 5 clearly shows, is but 10°. The following species were collected at locality 40x:

Astreopora cf. *myriophthalma* Lamarck.
Fungia cf. *decipiens* (K. Martin).
Madrepora duncani Reuss.
Arca sp.
Dosinia sp.
Cerithium bandongensis K. Martin.
Conus sp.
Cypræa sp.
Natica sp.
Vicarya callosa Jenkins.

[8] Iddings, J. P., The petrography of some igneous rocks of the Philippines. Philip. Journ. Sci. § A 5 (1910) 169.

About 100 meters south of the fossil locality 40x, Mr. Graham B. Moody and Dr. W. D. Smith found andesite in a creek bank, elevation 900 meters (3,000 feet, aneroid). Mr. Moody stated that the andesite was in place and was probably instrusive in the Vigo. Since a residual of Malumbang limestone occurs at 1,065 meters (3,550 feet, aneroid) and possibly rests upon the andesitic dike, it seems quite probable that the andesite is of post-Vigo and pre-Malumbang age. Doctor Smith has kindly examined a thin section of this rock and described it as follows:

This is a badly weathered andesite consisting largely of glassy feldspars, sanidine, in a glassy groundmass in which one sees grains of magnetite, flakes of some ferromagnesian minerals, either pyroxene or hornblende. The feldspars even in the fresher-looking portions are somewhat decomposed, while in the outside portions of the specimen they are completely kaolinized, giving a whitish appearance to the rock. This rock would be classed in the older terminology as trachyte.

About one kilometer east of locality 40x, at a coal prospect made by Governor Whitmarsh's men, a black lignitic sandstone and a black lignitic shale with a strike of north 30° west and a dip of 40° west were noted. The intervening area was evidently sandstone and shale of the Vigo group.

In a creek at an elevation of 1,086 meters (3,620 feet, aneroid), 1.5 kilometers east of locality 40x, dark lignitic sandstone occurs in fault contact with a coarse conglomerate whose bowlders are composed of diorite and andesite. Thirty meters (100 feet) below, Mr. Moody obtained a dip of 30° south. Governor Whitmarsh found a large specimen of *Vicarya callosa* here, but when we visited the locality no fossils were obtained.

VIGO FAUNA

Another very interesting locality was discovered by Mr. James Wright, superintendent of the Trinidad Agricultural School, and Mr. Charles Mitchek, the foreman in charge of the stock farm. This locality is 200 meters north of the stock-farm buildings and was uncovered while they were attempting to develop water by an open cut in a small creek. The strata exposed in the small creek consist of coarse arkosic sandstone which in places is decidedly argillaceous. The structure in this vicinity is highly complicated by faulting. The strike is practically due north and south with a dip of 20° west. In the hills 0.8 kilometer east of this point, this arkosic sandstone is interbedded with tan tuffaceous marl exactly like the marl exposed in the intersection of the Naguilian and Campo Filipino Roads.

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From this locality 200 meters north of the stock farm, 68x, the following fauna has been obtained:

Fungia sp.
Porites (?) sp.
Arca ferruginea Reeve.
Avicula sp.
Clementia papyracea Gray.
Cardium sp.
Dosinia lenticularis Sowerby.
Macoma sp.
Dentalium heptagonum Boettger.
Bullaria sp.
Cassidaria sp.
Cerithium javanum K. Martin.
Cerithium jenkinsi K. Martin.
Clavella sp.
Columbella bandongensis K. Martin.
Conus cf. *hardi* K. Martin.
Conus javanus K. Martin.
Mitra javana K. Martin.
Nassa cf. *costellaria* A. Adams.
Nassa crenulata Bruguiere.
Natica sp.
Nyctilochus (*Tritonium*) sp.
Sigaretus sp.
Strombus cf. *swainsoni* Reeve.
Vermetus javanus K. Martin.
Vicarya callosa Jenkins.

This fauna is clearly referable to the Vigo-Miocene.

LIMESTONE AND CONGLOMERATE OF MALUMBANG-PLIOCENE AGE

The most-prominent topographic features of the Baguio Plateau are connected with the erosion forms of the Malumbang coralline limestone, Mount Mirador, and Trinidad Valley. The best section for the study of this formation is found in the gorge of Trinidad Valley (Plate 5, figs. 1 and 3).

MALUMBANG FAUNA

The coralline limestone in this vicinity has yielded a fauna equivalent to that of the Malumbang formation of Pliocene age.

AREAL DISTRIBUTION OF MALUMBANG FORMATION

While in Baguio during December, 1920, Mr. John Reavis told Dr. Warren D. Smith and the writer of an interesting occurrence of fossils at his place, Klondike's Springs, in lower Bued River Cañon (Plate 6, fig. 1). On our way to Manila we investigated this locality; although the fossils found in the conglomerate were sparse, we succeeded in finding several fragments of coral rock which contained several species of coral.

These species are forms common in the Malumbang-Pliocene, and they represent either reworked Malumbang limestone after uplift and subsequent erosion or fragments broken off of coral reefs which lived in the Malumbang sea and were washed into a gravel beach that existed during Malumbang time. It is evident that many of the folded strata in Bued River Cañon are much younger than was previously thought and that the greatest possible age assignable for these conglomerates at Klondike's Springs is Malumbang-Pliocene. As suggested

above, these beds might be younger still. After much searching a species of *Pecten* was found in the sandy matrix of the conglomerate, so the conglomerate is thus proven to be marine. Both Doctor Smith and the writer regard these strata at Klondike's Springs as being of Malumbang-Pliocene age and as having been formed contemporaneously with Malumbang-Pliocene limestone; that is, as a pebble beach equivalent of a coral reef of Malumbang time rather than later deposits.

The strata at Klondike's Springs dip 25° west and strike north 38° west and are in the middle of a well-exposed section, excellently dissected by Bued River. At least 300 meters of conformable strata are above this locality, and apparently a minimum of 450 meters below it.

The Malumbang limestone has a much greater distribution than was previously recognized. The belt extending from a locality about 3 kilometers south of Mount Mirador to a point about 3.2 kilometers north of Trinidad Valley is the striking and well-known exposure. In a reconnaissance trip to the top of Mount Santo Tomas, Mr. Graham B. Moody, Mr. Palmer Beckwith, Dr. W. D. Smith, and the writer discovered several small blocks of Malumbang limestone. The tuffs of the Baguio formation were noticed at kilometer 5, but a short distance beyond and at kilometer 6, elevation 1,820 meters, aneroid, limestone was found. At locality 42x a fine specimen of *Leptoria* sp. was collected. A small collection of corals was made at 7.75 kilometers from Baguio, elevation 1,536 meters (5,120 feet). At locality 43x a branching coral, of a species that is common in the Malumbang formation, was collected. Between localities 42x and 44x the hill tops are composed of coralline limestone, but at 1,560 meters (5,200 feet), a short distance beyond locality 44x, an abrupt change in topography occurs; andesitic conglomerate is found, and the trail zigzags up a very steep face. This is caused by a comparatively recent fault at that point. Farther on, andesite is found at kilometer 11, elevation 1,950 meters (6,500 feet, aneroid); and a short distance beyond, about halfway between posts 11 and 12, coralline limestone again occurs, on top of the hill, locality 45x. From this point the trail descends slightly, and between posts 12 and 13 andesite again outcrops in a steep hillside. The contact between the last-named localities is marked by a fault (Plate 6, figs. 1 and 3). Resting upon the andesite is a considerable thickness of andesitic conglomerate. The slope then changes, and for a short distance the ascent is gradual. Suddenly, the

trail begins to zigzag, and another abrupt change occurs. No evidence of faulting was found except this sudden topographic change, but taken with the faults previously observed the writer regards the point of change as marking a fault. In this final steep climb to the top of Mount Santo Tomas andesitic agglomerate, andesite, and andesitic conglomerate were successively noted. The last-named member has a steep westerly dip of 78°. The andesite and andesitic conglomerate may be pre-Malumbang in age, and associated with the Vigo in part as intrusives. Practically the same types of andesite, andesitic agglomerates, and andesitic conglomerates are found on the east side of Bued River Cañon at the Copper King mine, now known as the Demonstration mine, where this material is probably in fault contact with a coarse sandstone of possible Vigo age, since pebbles of diorite, apparently derived from the basement complex of diorites and schists, were embedded in it.

At the foot of the Zigzag on the Baguio Road in Bued Cañon a dark gray to black limestone occurs (Plates 1, 2, and 7). This limestone yielded the following fauna:

Stylophora cf. *mordax* Dana.
Avicula sp.
Clementia papyracea Gray.
Mactra (?) sp.
Tellina sp. *a*.
Tellina sp. *b*.
Venus purpera Linnæus.

This fauna is referred to the Malumbang, and the dark color of the limestone is probably due to infiltering waters.

BAGUIO FORMATION

Andesitic tuffs and breccias of late Pliocene or early Pleistocene age which rest unconformably upon marl of the Malumbang formation are assigned to the Baguio formation of Smith. The writer does not limit this formation to that portion containing silicious-spring deposits, but regards the silicious-spring material as a later and adventitious deposit of no great importance from the point of view of the student of historical geology. This use of the term "Baguio formation" is much broader than that of Smith, who first used the name; but, since the city of Baguio is built upon these andesitic tuffs, agglomerates, and breccias, and these rocks are finely exposed here, the writer thinks best to extend the name. Eveland's reconnaissance map of the Baguio region shows the areal extent of this formation. The materials in this formation were practically all derived from a neighboring volcano or volcanoes, and apparently all were deposited upon land or in shallow lakes. Certain outcrops

of the andesitic tuff, notably the cut in Trinidad Road 0.5 kilometer north of Baguio City Hall, are well bedded and show considerable sorting, thus indicating that these deposits were probably laid down in a lake or in the low, flat valleys of that time. However, the road exposures near the Pines Hotel show another method of deposition. Here occur large angular and subangular fragments of a solid andesite embedded in finer tuffs. These deposits probably represent an agglomerate formed as a volcanic mud flow. The third notable phase is a very hard andesitic breccia composed of angular andesite fragments varying from 5 to 10 centimeters in greatest dimension.

STRATIGRAPHIC RELATIONS OF BAGUIO FORMATION TO VIGO AND MALUMBANG

The relations between the Malumbang formation, Vigo group, and the Baguio formation (as revised below) were obscure to Eveland and Smith, since at Trinidad, where the formations are well exposed, the contact is a fault. Also, the Malumbang-Baguio contact, 100 meters north of the provincial building at Trinidad, is likewise a fault. When the writer attempted to map a small area in the vicinity of Mount Mirador and Trinidad Valley in detail, it was evident at once that the Baguio formation rested with marked unconformity upon Malumbang limestone and the Vigo group. The small outliers of Baguio formation along the Mount Mirador Road and the road to Dominican Hill demonstrate this relation clearly. In tracing the contact between the Malumbang limestone and the Baguio formation on the west side of Trinidad Valley, the writer, accompanied by Mr. James Orbison, located several residuals of the Baguio formation resting upon unconformably Malumbang limestone (fig. 3). The nature of the contact near the alluvium of Trinidad Valley clearly demonstrates this relation, although a portion of the contact at a point 4.8 kilometers south of Trinidad is a small fault. The relations between the Baguio formation and the Vigo were discovered when Doctor Smith and the writer examined a fossil locality which was previously located as being in the tuff of the Baguio formation, but which proved upon reëxamination to be a marl member of the Vigo-Miocene. This marl member in the local field is associated with arkosic sandstone in the vicinity of Trinidad Farm School, where a characteristic Vigo fauna containing *Vicarya callosa* has been obtained. The marl member exposed along the Naguilian Road at Campo Filipino Road, 1 kilometer west of Baguio City Hall, yielded numerous casts of marine Pelecypoda

and Gastropoda where it is unconformably overlain by andesitic tuff, a member of the Baguio formation. The irregular, unconformable contact at this place is marked by the dark brown

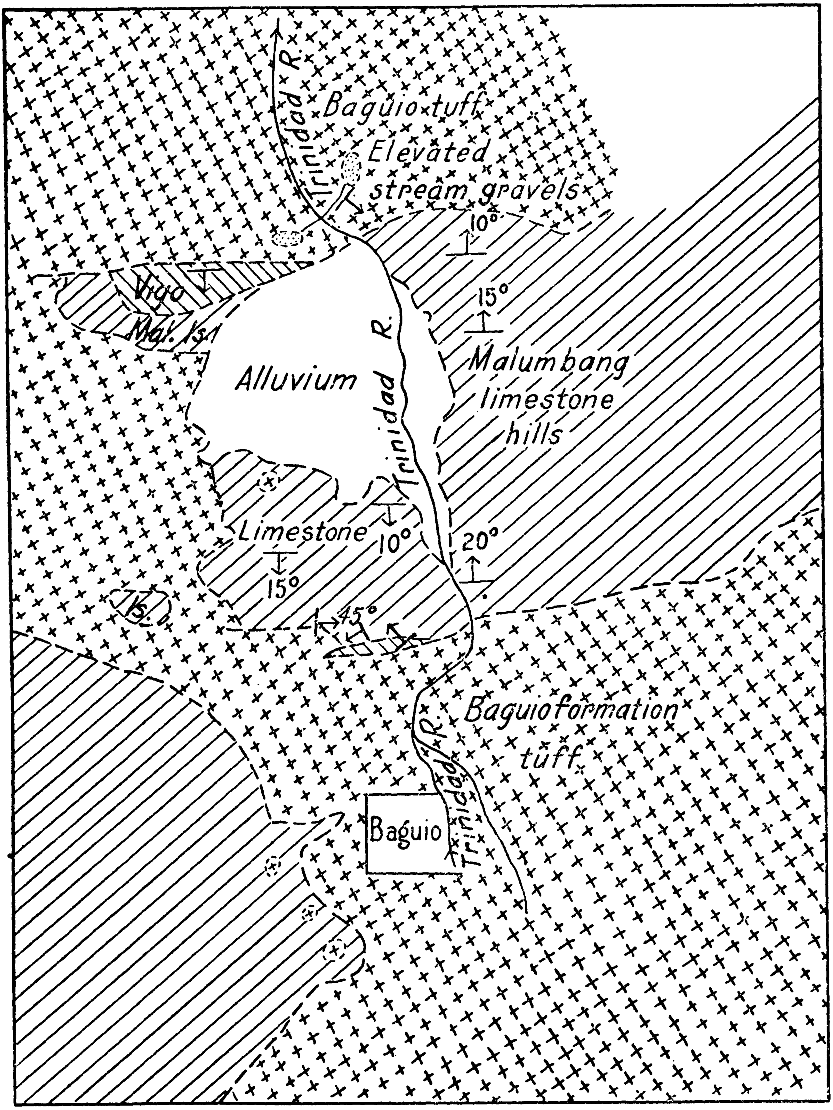

FIG. 3. Geologic sketch map of Baguio and vicinity.

soil resting upon yellow marine marl. Fragments of the tuff and agglomerate of the Baguio formation, in turn, rest upon and are embedded in this soil.

FAULTING AND LANDSLIDES IN THE BAGUIO FORMATION

The tuff members of the Baguio formation in and around Baguio do not exhibit any regularity in dip and strike, but vary greatly from place to place. These variations suggest many local minor faults, in addition to the well-marked contact faults mentioned above. These minor faults may be due in part to local slumping after the limestone beneath the Baguio formation had become cavernous. Doctor Smith has advanced the same hypothesis to account for the Hospital Hill slides. His statement, in litt., is as follows:

The head of Bued River Cañon is marked by some very interesting landslides, which not only are producing some rather pronounced changes in the topography of that region but have also become of first importance since some Government public buildings have been endangered.

Just before one reaches the Baguio Plateau proper traveling along the Benguet Road, one climbs to a bench that is largely due to subsidence of material from the valley sides. There is a broad amphitheaterlike area here 2 or 3 miles in length and a mile or so wide which remarkably simulates the cirquelike heads of glaciated streams. At the upper end of this valley there is a huge crack or series of cracks which run around these hills about as the "bergschrund" found at the head of glacial cirques does. On the west side of the Benguet Road the greatest slip can be easily studied. There is a fault here in loose tuff, sinter, and volcanic breccia amounting to at least 50 meters. The slip plane has an angle of from 55° to 60° and at this point trends north and south. In January, 1915, Mr. V. E. Lednicky, formerly of the Bureau of Science, was called upon to report upon the Hospital Hill slide. The writer visited this region during several seasons previous to that time, and during one of these visits, in the spring of 1914, he measured the subsidence, which then amounted to 35 feet, and the rate of movement, which at that time was 1 inch an hour. As this material is all very loose and only held together by clay, it is absolutely certain that there will be other slides behind the present one and the hospital buildings, unless moved, will ultimately be wrecked. [Plate 8, fig. 2.]

This subsidence is due to several factors. Undoubtedly the saturation of these loose materials with water and the high angle of the valley walls, which are far above the angle of repose, are important causes, but the ultimate cause probably is the solution of limestones at the bottom of Bued River Cañon, notably at the foot of the Zigzag, which would permit of the leaching out of the rocks and thereby cause the slumping of the material from above.

Similar and even greater slides occur much farther north in the Mountain Province. A notable one at Sagada extends over even a larger area, where the amount of subsidence in 1914 amounted to over 30 feet. The fault crack, following the periphery of the valley head, was when seen by the writer at least 2 miles long and a large Igorot village was gradually settling into the cañon without any particular disturbance of the inhabitants. Some time previously the Catholic church which

had been located, unknowingly, over the fault line was tipped over at a considerable angle and partially wrecked and had to be abandoned.

Many of the plateaulike areas in northern Luzon and especially many of the benches in the valleys are due in part to fill as a consequence of these enormous subsidences of the loose, saturated terrane. These slides will not cease until the angle of repose for that kind of material is reached.

The writer is in agreement with these views concerning the hospital slide, which were expressed in the field by Doctor Smith before the unconformity between the Baguio formation and the underlying Malumbang was discovered. Since the limestones at the foot of the Zigzag are now recognized as Malumbang-Pliocene, and not Eocene as was previously suggested, this hypothesis is still further strengthened.

FLORA

Science is greatly indebted to Father Francisco de P. Sanchez, of Ateneo de Manila, for his efforts and care in collecting paleontologic specimens in the vicinity of Baguio. Dr. W. D. Smith and the writer had the privilege of studying Father Sanchez's collections on exhibition in the museum on Mount Mirador, Baguio. Of particular interest in this collection was a flora obtained from the Baguio formation, from Government Center quarries, about 1.6 kilometers east of Mount Mirador. The following species were identified for Father Sanchez by Mr. E. D. Merrill, director of the Bureau of Science:

Vaccinium cumingianum Vidal.
Clethra lancifolia Turcz.
Machilus sp.
Elæocarpus argentea Merr.
Ardisia sp.

The specimens were obtained from the silicious facies of the Baguio tuffs and, according to Mr. Merrill, the species are essentially those of an upland flora (Plate 10, fig. 1).

PLEISTOCENE

STREAM GRAVELS

Prominent stream terraces, much dissected, occur in the middle course of Bued River. The coarse gravels of these terraces are in places 6 to 9 meters thick, and they rest with marked erosional unconformity upon the andesites and andesitic breccias in that part of the cañon 15 to 30 meters above the river. With little doubt, these terraces register a rest period in the general uplift of Pleistocene time, during which a fairly wide valley bottom was developed. The terraces may correspond to a vague secondary level in the upper Bued River region below the Ba-

guio Hospital. This region is so much altered by extensive landslides in the Baguio formation that a definite decision is unwarranted.

DEVELOPMENT OF BAGUIO PLATEAU

GENERAL STATEMENT

The abruptness with which Baguio Plateau first strikes even the casual tourist is a noteworthy incident, which is punctuated by the chauffeur's suddên shifting into high after a long steady grind in intermediate or low gear up the tortuous, steep grade of the Zigzag of the Bued River Road. (See Plate 8, fig. 1.) A feeling of relief from strain on the part of the "back seat drivers" is notable as well, since the chauffeur rounded many of the curves with but little to spare, and visions of an overturned car in the deep cañon below have appeared to the timid. In December the late evening air, filled with the healing odor of pines, has a snap to it quite reminiscent of the temperate homeland. The American takes a new lease on life and realizes that he is truly not in the Tropics. The papaya, the banana, the coconut palm, and the graceful festooned bamboo of the lowlands and the vine-entangled, thickly foliated tropical forest of Bued River Cañon are no longer a part of the scene, but an open pine forest with a grass carpet clothes the low, beautifully rounded hills and wide, gently sloping valleys of this land, which is truly a fairyland after a couple of years spent in the enervating humid heat of the Philippine lowlands. Only once before has the writer experienced such a striking contrast, and that was when he descended in three hours from a 2,040-meter (6,800-foot) elevation, the snow-covered edge of the Colorado Plateau, to the warm desert river 1,440 meters (4,800 feet) below on a day in late December. Both incidents were exhilarating and impressive, but the restfulness of Baguio Plateau imparted to the individual a feeling of security not felt in the Colorado Cañon, where the very plants and animals were fiercely struggling for existence in an arid surrounding, forbidding but grand.

The uniqueness of Baguio Plateau appears even greater after short excursions in the vicinity are taken. A walk out Bua Road to the plateau edge enables the geologically trained visitor to see even better the sharp contrast between the plateau and the deep eroded V-shaped gorges of Gold Creek and Antamok River. A further stroll to the hilltops of Pakdal thoroughly convinces him that these well-rounded hills belong with the Baguio Plateau and represent the uplands of this once low-lying country.

A tramp along Mount Santo Tomas Trail confirms this view, and from the upper elevations the hanging valley of Loacan is also recognized as an old wide stream valley robbed of its headwaters by some piratical tributary or tributaries of Gold Creek and left hanging on the wall of Bued River Cañon through a process of rapid erosion of the master stream (Plate 9, fig. 1, and Plate 10, fig. 2).

An automobile ride from Baguio to Trinidad with its astonishing variety of scenery, the gently rolling valley and hills, the sudden entrance into the narrow shelf-cut road of Trinidad River Cañon and the equally sudden appearance of Trinidad plain impress all with their pleasing contrasts. A walk from the capitol at Trinidad for a short distance along the Mountain Trail demonstrates the great differences between the Baguio Plateau and Trinidad Valley and the sharply chiseled ridges and acute V-shaped valleys of the country traversed by the Mountain Trail. Such are the temptations placed before the student of historical geology and physiography which cause him to dream and embolden him to attempt a reconstruction of the Past.

LOACAN VALLEY

From the Mount Santo Tomas Trail looking eastward, one sees the splendid hanging valley of Loacan with its wide, gently sweeping slopes, and pictures of a quiet-flowing stream in the middle of a wide shallow valley of the New England country come to mind. The last impression at once fades when, upon rounding another turn of the trail, the steep cañons of upper Bued River come into view, and one sees the wall over which the now feeble waters of Loacan Creek descend abruptly to join the waters of the present-day Bued River. A short automobile drive through Camp John Hay across the easily eroded tuffs of the Baguio formation brings us to this valley. The slopes are those of early old age, but the stream now occupying the valley center is very small. A view at the upper part of the present valley clearly indicates that the piratical Gold Creek has successfully beheaded this ancient stream. The trend of the present Loacan Valley indicates a consequent southwestward-flowing stream, and the recent movements along the stream course athwart Mount Santo Tomas fault may have been the cause of the rapid capture of its lower portion. This explanation is even more apparent when one considers the highly youthful character of upper Bued River during the descent of the Zigzag.

In connection with this major faulting, incidental movements along the east and west cross faults which cut the Santo Tomas Trail probably occurred as well. Now pour into these newly formed trenches torrential tropical rains and with exceeding quickness a deep cañon is developed. If this reasoning be correct, then this faulting must have taken place during the late Pleistocene and may have been incidental to the general uplift of Baguio Plateau. Since earthquakes are frequently reported at Baguio, it is highly probable that seismic disturbances still continue along these faults at the head of Bued River. The fact that the hanging valley of Loacan still remains further indicates a late Pleistocene age for these events, since hanging valleys, like lakes, are but transient physiographic features. Faulting may also have aided Gold Creek and Antamok River in beheading the Loacan, as a very prominent northerly trending fault occurs in Antamok Valley near the Benguet mine. This fault has brought the older diorites in contact with the late Miocene andesites.

TRINIDAD VALLEY

The most-striking feature seen on the topographic map of Baguio Plateau is the wide, round, sparsely contoured spot indicating Trinidad Valley. Not only is this true upon the map, but the intelligent nontechnical visitor to this valley sees the striking contrast between the narrow gorge of Trinidad Creek and the even valley floor beyond. At once he seeks an explanation, and the current hypothesis of volcanic crater develops as soon as the craterlike form is observed. It is not the writer's intention to waste too much time bowling over a "paper man," but a little explanation is due the layman. If a volcano were suddenly formed in an area of nearly horizontal sedimentary rocks then, with the upthrust, the sedimentary rocks would be inclined away from the center of the volcano on all sides, and the lavas or mud flows would be poured out across the broken edges of the sedimentary beds and form lava or mud-flow slopes completely burying the sedimentary beds for a time. Later dissection after the volcano became dormant would partially exhume the sedimentary beds and a concentric arrangement would be found due to the more easily eroded sedimentary beds. Such a case occurs in the center of the Sacramento Valley, California. The Marysville Buttes, "the stump of an old volcano," consist of a central core of a coarse-grained lava, andesite, which was forced up in the valley floor, a ring of marine sedimentary rocks

which were upturned when the lava was forced out, and a ring of andesitic mud flows on the edge of the sedimentary beds of Knoxville-Cretaceous, Chico-Cretaceous, and Tejon-Eocene ages occur as a series of smooth rounded hills forming an interrupted ring 1.6 kilometers or less in width, in striking contrast to the resistant core and the outer ring of firmly cemented mud flows which dip in all directions from the central core at angles of 4° or 5°. A glance at the geologic sketch map of this Trinidad area shows that four formations occur here; namely, alluvium, coralline limestone, andesitic tuff-breccia, and tan marls and associated arkosic sandstones (fig. 3). The alluvium occupies the round or valley portion. The south and east sides and portions of the north and west sides of the valley consist of coralline limestones and associated marine shales and sandstones. The dominant dip of these beds on the east side of the valley is 10° to 15° north. Only that portion of the valley out of which Trinidad River escapes is hard andesitic tuff-breccia (Plate 10, fig. 3). If a volcanic crater exposed sedimentary beds upon its walls, then the dominant dip would be away from the crater in all directions and lavas would be found resting upon such sedimentary beds. Such is not the case at Trinidad. Von Drasche regarded Trinidad Valley as a coral atoll, because coralline limestones border it. Interesting as this view would be, field evidence does not offer it much support. The presence of andesitic tuff-breccia on the north side in fault contact with coralline limestones, the prevailing north dip of the shales, sandstones, and coralline limestones on the entire east side of the valley, their much steeper dip than that of depositional coral-reef material, and the alternation of sandstones, shales, and limestones, are not characters of a coral atoll. Furthermore, the coralline limestone is too largely composed of rolled coral fragments, and no evidence was found to indicate that the corals were in place.

What then is the explanation of this most extraordinary, round, alluvium-covered valley surrounded on all sides by hills and steep-walled mountains? After a cursory study of the valley, the writer was early impressed with the fact that it was neither a volcanic crater nor an atoll, but was due to some peculiar erosional development. As outlined above, the sharp contrast upon entering and leaving this valley is striking, even to the casual visitor. Viewed from the hills above Trinidad, looking southward up the Trinidad Gorge and to the hills of Baguio in the distance, the terrace condition of the east portal of Tri-

nidad Water Gap is very evident and this elevation of 1,450 meters (4,850 feet). fits in nicely with the low-lying hills of Baguio beyond (Plate 11, figs. 1 to 3). When the stream cut this terrace at 1,450 meters (4,850 feet) the country evidently was at an elevation near sea level, and the course which the stream picked out across a country that was then largely covered by the tuffs and tuff-breccia of the Baguio formation and its alluvial derivatives was an accidental one. After uplift, the stream had sufficient volume to maintain its course and within its former wide valley now represented by the residual at 1,450 meters (4,850 feet) dug a cañon for itself. With uplift, the erosive power of the stream was greatly increased and this cañon was further developed. This downward cut of the stream may be likened to a band saw against which a board is thrust. As the saw descends through the board, a knot, soft dry-rotted spots, and wood of medium grain are successively encountered. A sharp narrow slot is cut into the knot, the saw may be bent from its course as it passes through the soft dry-rotted portion, while in the clear-grained wood a slot of moderate dimension is cut. Similar conditions, with differences in hardness, occur in the vicinity of Trinidad Valley. The andesitic tuff-breccia north of Trinidad corresponds to the knot. The compact, resistant coralline limestones of the water gap at the south entrance of Trinidad Valley represent another such development. The soft incoherent tuffs on the west side of Trinidad Valley are analogous to the soft dry rot in the timber. The unusually hard andesitic tuff-breccia north of Trinidad acted as a temporary dam, that is, in technical language, set up a local base level of erosion. The stream above this dam was at times temporarily restrained from downward cutting and then began to swing from side to side, developing broad meanders, now represented by somewhat distinct terraces on the side of Trinidad Valley. Since the softer material was on the western side and the harder material on the eastern, this horizontal cutting was chiefly confined to the western side.

Baguio Plateau was not elevated at one stage, since two terraces noticeable on the hills bordering Trinidad Valley represent in all probability two uplift stages. The third uplift is probably represented by the present valley development. As Trinidad River cuts through the north water gap again the dam will be lowered and in future geologic time Trinidad Valley will disappear. This explanation is chiefly physiographic, so direct geologic evidence of Pleistocene stream terraces containing

reworked material derived from the older formations was sought.

In company with Dr. Warren D. Smith, Trinidad Valley was studied in detail in the last two days of May, 1922, and conclusive proof concerning the development of this unique valley was obtained at this time. Reference to the geologic map of this vicinity brings out the fact that the western side of the valley is composed of the soft incoherent facies of the Baguio formation, in striking contrast to the compact and more-resistant limestones which are found on the eastern side of the valley (Plate 12, fig. 1). As was pointed out above, Trinidad River cuts directly across the compact, thoroughly indurated facies of the Baguio formation—a tuff-breccia. This tuff-breccia has a distinctly bedded appearance, with a strike about north 45° east and a dip of 15° southeast, in very evident contrast to the northerly dip of the coralline limestone on the east side of Trinidad Valley. Doctor Smith was skeptical concerning the writer's explanation of the development of the Trinidad River gorge north of the capitol of Benguet Subprovince at Trinidad, so that prominent hill with an elevation of 1,410 meters (4,700 feet) 1.2 kilometers north of Trinidad was investigated. On the east side of this hill at an elevation of 1,380 meters (4,600 feet) the writer obtained a good-sized piece of Malumbang-Pliocene limestone in bowlder form, and this evidence as representing Pleistocene stream gravel was accepted by Doctor Smith. The hill 0.4 kilometer northwest of Trinidad was next climbed, and again the writer succeeded in obtaining excellent fragments of limestone at 1,395 meters (4,650 feet) elevation. Upon climbing the hill 30 meters higher, at 1,425 meters (4,750 feet) elevation, Doctor Smith began finding fragments of well-rounded limestone, quartz, and andesite typical of the pre-Malumbang andesite, and was then convinced that Trinidad River was truly an antecedent stream intrenched in its present position, and that the stream gravels represented a Pleistocene formation resting unconformably upon the Baguio formation at these points.[9] After this discovery, Doctor Smith picked out two distinct terraces encircling the valley on the east, west, and south sides, which were approximately 60 and 90 meters (200 and 300 feet) above the valley floor, whose elevation is 1,320 meters (4,400 feet). In the afternoon Doctor Smith, Mr. James A. Wright, and Mr. Charles Mitchek visited

[9] The areas on the map representing this Pleistocene formation are considerably exaggerated in size.—R. E. D.

the Vigo-Miocene fossil locality which is located about 200 meters north of the stock-farm buildings. In this vicinity the gap between the drainage toward the China Sea and Trinidad Valley is exceedingly low, and both Doctor Smith and the writer were agreed that this gap had been lowered long after Trinidad River was firmly intrenched in its present course. The hard, resistant, andesitic tuff-breccia north of Trinidad has undoubtedly acted as a dam, creating at times a well-marked, local base level. This dam may have been renewed by faulting. The two terraces encirling Trinidad Valley probably represent substages in the general uplift of Baguio Plateau and the very notable plateau at Amsalsal and its correlative terrace 8 kilometers (5 miles) north are probably referable to one of these substages. The present floor of Trinidad Valley consists of thick alluvium which in the temporary marshlike area, now being drained through the energy of the farm-school management, is decidedly peaty. The writer interprets this marshy area, 0.4 kilometer southwest of Trinidad, as representing the abandoned channel of Trinidad River when that river had a course around the western side of the valley.

In summary, then, Trinidad Valley is neither an extinct crater nor an atoll but is a peculiar erosional development due to an antecedent stream which in its successive intrenchments exhumed the older formations. This valley gives additional confirmatory proof that the Baguio Plateau surface was developed at elevations probably varying from sea level to 360 or 450 meters (1,200 or 1,500 feet), since its development can be explained in no way except through general regional uplift.

MINOR MODIFICATIONS

Since the Baguio Plateau has been uplifted, minor modifications of its surface have occurred, but these changes are not sufficient to obliterate the record. The sources of Trinidad River are cut into the original surface for depths of 60 to 90 meters (200 to 300 feet). Besides these erosional changes some of the local subsidences, such as the pond near the Pines Hotel and the sink near Mount Mirador, are due to the solution of the underlying Malumbang limestone (Plate 12, fig. 3). Some of the local earthquakes at Baguio have been ascribed to this cause, and some of the minor shocks may be thus explained. The more likely explanation is that the heavier shocks are results of movements along the Recent and late Pleistocene faults, such as those of Mount Santo Tomas. Doubtless certain slides, rock falls, and incidental after-adjustments have exerted their influence upon Baguio Plateau in minor degrees.

EXTENT OF BAGUIO PLATEAU

The interesting work of Doctor Smith in the vicinity of Mount Data, which he has kindly permitted the writer to use in this paper, demonstrates that Baguio Plateau extended in a northerly direction for at least 120 kilometers. How much farther north it extended, future exploration may reveal. Concerning the southerly and easterly extent of Baguio Plateau no definite evidence is available, but from the researches in another field of science, that of botany, some idea may be gained.

THE PRESENT UPLAND FLORA OF BAGUIO PLATEAU AND BENGUET AND ITS DEVELOPMENT

The temperate-zone aspect of the trees and scenery of Baguio Plateau interest all Americans who visit this unique spot, and the origin of this flora stimulates scientific imagination. If it be truly a temperate flora, at what geologic time was it established and how was it maintained during the Pleistocene? Is it possible that the flora demonstrates that high mountains have been present in northern Luzon since the beginning of the Miocene? A really temperate flora could scarcely survive the warmth of the Philippine lowlands even of Pleistocene time. Such were the questions the writer brought to Mr. E. D. Merrill. In reply Mr. Merrill has written the following statement:

The flora of the Benguet-Bontoc region, an area essentially characterized by the dominance of a species of pine, *Pinus insularis* Endl., is in striking contrast to that of other parts of the Philippines, presenting very numerous northern types that do not occur elsewhere in the Archipelago and indicating a derivation, so far as these northern types are concerned, from the central mountain mass of Asia, many of the same types being found in China, Japan, and the Riu Kiu Islands, and most of them in Formosa. Northern Luzon and Formosa, in numerous cases, present the most southern and eastern extension of the Himalayan flora, many of the Himalayan types found here not extending into the Malay Archipelago. Practically all of the Himalayan types found in northern Luzon also occur in Formosa, as noted above.

About five hundred species of plants in the higher groups are known in the Philippines only from the Benguet-Bontoc region, indicating a distinctly specialized flora. Approximately three hundred fifty of these, or 70 per cent, are endemic so far as the Philippines are concerned, while the remaining 30 per cent are found outside of the Archipelago, chiefly in India, China, Japan, and Formosa. A very few species and genera extend south of the Mountain Province on the higher mountains, some even occurring at higher altitudes in Mindanao, and a few extend as far

south as Celebes and Timor. This indicates a very long period since the original plants came into the Philippine Islands, allowing for the development of very numerous endemic species and no less than six endemic genera.

If we examine the flora of the Benguet-Bontoc region by larger groups, for example, families, we find two striking facts. The families essentially characteristic of the temperate regions are relatively strongly developed, while the families highly developed in tropical regions are very poorly represented. Thus, such essentially temperate families as the following seventeen are well represented in the Benguet-Bontoc region:

Pinaceæ (one species of *Pinus*, but dominant).
Gramineæ.
Cyperaceæ.
Juncaceæ.
Liliaceæ.
Caryophyllaceæ.
Ranunculaceæ.
Berberidaceæ.
Saxifragaceæ.
Rosaceæ.
Violaceæ.
Ericaceæ.
Primulaceæ.
Gentianaceæ.
Labiatæ.
Scrophulariaceæ.
Compositæ.

In contrast to this, the families that are in general strongly developed at low and medium altitudes in the Philippines and in other tropical countries are either entirely unrepresented in the Benguet-Bontoc region or are represented only by few species, practically none of the few species that do occur there being confined to the Benguet-Bontoc region. Perhaps the most striking case is the Dipterocarpaceæ, the family being represented in the Philippines by nine genera and about fifty species, and dominant in the primary forests of the entire Archipelago at low and medium altitudes. No representative of the family is known from the region under discussion. The twenty-four tropical families either unrepresented or very poorly represented in the Benguet-Bontoc region are as follows:

Pandanaceæ.
Palmæ.
Nyctaginaceæ.
Anonaceæ.
Myristicaceæ.
Capparidaceæ.
Connaraceæ.
Meliaceæ.
Sterculiaceæ.
Malvaceæ.
Dipterocarpaceæ.
Ochnaceæ.
Guttiferæ.
Dilleniaceæ.
Flacourtiaceæ.
Lecythidaceæ.
Combretaceæ.
Sapotaceæ.
Ebenaceæ.
Apocynaceæ.
Convolvulaceæ.
Verbenaceæ.
Bignoniaceæ.
Acanthaceæ.

If we examine the geographic distribution of smaller groups, that is, the genera, we find that the same fact holds true. It is unnecessary to enumerate here the very numerous essentially tropical genera which occur elsewhere in the Philippines but which do not occur at all or, if present, then very poorly represented in the Benguet-Bontoc region.

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The following seventy genera are essentially confined to the Benguet-Bontoc region so far as their occurrence in the Philippines is concerned:

Taxus (also on Mount Banahao)[10].
Pinus (also in Zambales and one species in Mindoro).
Agrostis.
Aniselytron.
Arundinaria.
Brachypodium.
Bromus.
Calamagrostis.
Chionachne.
Deschampsia.
Microlaena.
Monostachya.
Poa.
Luzula.
Aletris.
Asparagus.
Disporum.
Lilium.
Liriope.
Saururus.
Thesium.
Arenaria.
Sagina.
Stellaria.
Anemone.
Ranunculus.
Thalictrum.
Berberis.
Mahonia.
Sedum.
Astilbe.
Deutzia.
Fragaria.
Rosa.
Dumasia.
Lespedeza.
Shuteria.
Boenninghausenia.
Skimmia.
Sarcococca.
Pistacia.
Vitis.
Daphne.
Carionia.
Epilobium.
Acanthopanax.
Loheria.
Swertia.
Petalonema.
Bothriospermum.
Calamintha.
Plectranthus.
Teucrium.
Alectra.
Bythophytum.
Ellisiophyllum.
Hemiphragma.
Veronica.
Galium.
Peracarpa.
Lonicera.
Ainsliaea (also on Mount Banahao).
Anaphalis.
Aster.
Senecio.
Ethulia.
Carpesium.
Cirsium (also on Mount Banahao).
Merrittia.
Solidago.

It will be noted that practically all of these genera are those that are characteristic of the North Temperate Zone and poorly represented in tropical regions. Six genera, *Aniselytron, Monostachya, Carionia, Loheria,*

[10] Mount Banahao is an extinct volcano of Recent and Pleistocene ages, having an altitude of 2,188 meters, situated on the border of Laguna and Tayabas Provinces, about 350 kilometers south of Baguio. Three northern types occur at or near the summit of this mountain, but not elsewhere south of Benguet. They are *Taxus wallichiana* Zucc., *Cirsium philippinense* Merr., and *Ainsliaea reflexa* Merr., the first bird-distributed, the last two wind-distributed species.

Petalonema, and *Merrittia*, are monotypic, and are confined not only to the Philippines, but also to the Mountain Province.

In addition to these genera, other essentially temperate or subtemperate groups are much more strongly developed in the Benguet-Lepanto region than in other parts of the Philippines, being represented there by from one to several species, elsewhere in the Philippines usually by one or few forms and chiefly at higher altitudes farther south. They are—

Potamogeton.	*Gentiana.*
Carex.	*Cynoglossum.*
Juncus.	*Ajuga.*
Rubus.	*Salvia.*
Smithia.	*Sophubia.*
Impatiens.	*Mosla.*
Hypericum.	*Lobelia.*
Viola.	*Bidens.*
Vaccinium.	*Gnaphalium.*
Rhododendron.	*Artemisia.*
Lysimachia.	*Eupatorium.*

Australian types are poorly represented by two species of *Halorrhagis*, one endemic, the other extending from India to Japan southward to New Zealand, and *Uncinia rupestris* Raoul, in Luzon, Australia, and Hawaii. *Gaultheria borneensis* Stapf, known from Borneo (Mount Kinabalu), Formosa, and Benguet, is most closely allied to a New Zealand species. Our two endemic species of *Ranunculus*, confined to the Benguet-Bontoc region, find their closest allies in Australia and New Zealand, not on the Asiatic Continent.

Baguio Plateau, in a restrictive sense, is characterized by the dominance of *Pinus insularis*. In general, the flora of Baguio and vicinity, including Mount Santo Tomas, is very similar to that of other parts of the Mountain Province, lacking, however, certain genera that are found on the higher mountain peaks north of Baguio; namely, *Aniselytron*, *Anthoxanthum*, *Deschampsia*, *Monostachya*, *Poa*, *Luzula*, *Saururus*, *Ranunculus*, *Sarcococca*, *Loheria*, *Bythophytum*, *Peracarpa*, and *Solidago*. These genera, however, occur at Pauai (Haight's Place), on Mount Pulog, and on other high mountains in northern Benguet, in Lepanto, Bontoc, etc. Generally speaking, the Baguio flora is characterized by the occurrence of the genera enumerated for the Benguet-Bontoc region as a whole, eliminating the thirteen genera just enumerated. In most cases the last thirteen genera are represented in the Philippines by one species only; *Luzula* and *Ranunculus* have two species each. Tropical types, that is, families, genera, and species essentially characteristic of the Malayan Archipelago and the low altitudes of the Philippines, are no more prominently represented on the Baguio Plateau than they are in any other part of the Mountain Province.

Among the genera essentially confined to the Benguet-Bontoc region, so far as their occurrence in the Philippines is concerned, there are about seventeen that have adaptations for their dissemination through the medium of wind, and sixteen species which are apparently distributed by their fleshy fruits being eaten by birds. In the remaining thirty-seven cases no data are available as to adaptations for dissemination, although

it seems highly probable that many of the species may be distributed through their seeds being present in mud adhering to the feet or feathers of migratory birds, as in numerous cases very minute seeds are produced in great abundance, corresponding in general to the large series of rice-paddy weeds so predominant in the open low-country vegetation of the Philippines, and whose distribution can scarcely be explained on the basis of any other hypothesis than that just mentioned.

It is to be noted that the northern types are for the most part confined to the Benguet-Bontoc region in the Philippines. Many are essentially Himalayan, but others are confined to China and Luzon, Formosa and Luzon, and a few to Japan and Luzon. Practically all of the Himalayan types found in Luzon also occur in Formosa, indicating that they attained their present distribution at probably the same geologic time. It would seem that this might have been in the Oligocene or Lower Miocene age when Formosa and Luzon were connected with the Asiatic continent. These types may have at one time extended farther south, but if so, they have been exterminated by changes in climatic conditions. Very many of the Formosan-Luzon-Himalayan types are unknown from Sumatra, Java, and Borneo, and could scarcely have reached Luzon and Formosa through those islands. Summarizing, it would seem that from the time these Himalayan types reached the Philippines there has been continued high elevation in some part of the Benguet-Bontoc region, which has allowed them to persist. Most or all of them cannot grow under present climatic conditions at altitudes below 1,200 meters, while very many of them cannot grow below altitudes of 2,000 meters.

As far as Malaysia as a whole is concerned there were apparently two independent series of migration of Asiatic types, one through the Malay Peninsula to Sumatra, Java, Borneo, and the Philippines, and an earlier one through Formosa and Luzon to the Philippines, a few of which extended southward to Celebes.

Mr. Merrill's illuminating description clearly indicates that, at least since the beginning of the Miocene, mountains attaining elevations of 900 to 1,500 meters existed in Luzon. After the uplift of Baguio Plateau in middle or late Pleistocene time, the temperate flora from the greater heights of northern or southern Luzon invaded the newly formed Baguio Plateau, approved of its climate, and has continued to flourish there.

ACCELERATED TROPICAL PENEPLANATION

As was outlined in the introduction, the development of Baguio Plateau was rapid and the northern extension of this surface was great, according to Doctor Smith who correlates Mount Data Plateau with it. Now, the reader must remember that this surface cuts transversely the Baguio formation of probably late Pliocene or early Pleistocene age. This early old-age surface, or peneplain, was developed in the Pliocene, uplifted in the Pleistocene, and has over much of its former extent been chopped up into knife-edged mountain ridges 1,200 to 2,100

meters (4,000 to 7,000 feet) above sea level with deep 300- to 900-meter valleys between. Why, then, this great acceleration of geologic processes? Let us examine in detail the climate of this region.

CLIMATE OF BAGUIO PLATEAU

Baguio takes its name from the Spanish word for typhoon, "baguio," and deservedly so, considering the climate of this region. The excellent works of the Philippine Weather Bureau describe Baguio climate very well. Father José Coronas, chief of the meteorologic division of the Weather Bureau,[11] furnishes contrasting data between Baguio and other stations, as follows:

	°C.
Baguio, mean annual minimum	8.8
Manila, mean annual minimum	15.3
Baguio, annual normal	17.9
Manila, annual normal	26.4
Baguio, mean annual maximum	26.6
Manila, mean annual maximum	39.3

On page 337, Coronas summarizes these conditions as follows:

1. The mean annual temperature of Baguio, 17.9° C., differs from that of Manila by −8.5° C. The differences of the monthly means vary from −7.5° C. in December to −9.3° C. in May.

2. The mean annual range of temperature, that is, the difference between the mean temperature of the warmest month and the mean of the coldest month, is 2.4° C., somewhat smaller than that of other nearby stations on the sea level.

3. The lowest air temperature in 16 years has been 3° C. The mean of the annual minimum temperatures, however, is 7.4° C. for the first period of observations, and 9.9° C. for the second period. In our Temperature Map the mean of the two periods is given. The absolute minimum 3° C. was recorded in January, 1907, which was an extraordinarily cold year for Baguio.

4. Speaking in general, we may say of the temperature of Baguio that it is about 8 or 9 degrees lower than that of the other stations of Luzon on the sea level, but otherwise it follows the laws of a characteristically tropical climate as to the diurnal, monthly, and annual range, as to the warmest and coldest months of the year and the warmest and coldest hours of the day, etc., etc.

Before finishing this chapter, the attention of our readers should be called to a fact which may help to have a better knowledge of the climate of Baguio and may be of special value to agriculture. We had heard at times that real frost was observed and even a thin crust of ice formed in little pools at the foot of Mount Mirador, even when the air temperature both on the top of Mirador and in another station on a plateau near the City Hall was several degrees above the freezing point.

[11] The climate and weather of the Philippines, 1903–1918, The Philippine Census 1 (1920). In the temperature map, facing page 352.

During the winter of 1918 to 1919, the observer at Mirador, Mr. Pastor P. Daroy, made a series of observations which leave no doubt on this matter.

Temperature alone would not give Baguio its fine climate, but the fortunate distribution of rainfall or, rather, its concentration in July, August, and September leave the rest of the year balmy and pleasant, in marked contrast to Mount Banahao where, with even lower temperature, the rainfall is distributed throughout the year. Coronas in a note upon rainfall describes general conditions as follows:[12]

There cannot be any doubt that the most interesting feature of the climate of the Philippines is the monthly distribution of rainfall. If this element would be about the same throughout the Archipelago, there would hardly be any difference of climate in the Philippines. But as it is, the different position of the islands which makes them or part of them more or less exposed to the general winds prevailing in the Philippines, both in winter and in summer, is the principal cause of our different kinds of climate in spite of the relatively small extension of the Archipelago from east to west, especially in Luzon. In winter the rains of the Philippines are mainly due to the northeasterly air currents, which, coming directly from the Pacific, cause abundant rains to fall over the eastern part of the Archipelago. Hence they are sometimes called "NE monsoon rains." In summer and autumn our rains are mainly due to the influence of typhoons which either cross the Islands, generally from eastsoutheast to westnorthwest, or pass some distance to the north. These rains, though quite general throughout the Archipelago, are more abundant in Luzon and the Visayas, and exceptionally heavy at times in the western part of these Islands which is more exposed to the westerly and southwesterly winds. As the great majority of typhoons that occur from June to October pass to the NE or N of the Philippines or cross the northern part of Luzon, the winds from west and southwest are the most prevailing during that season. This summer and autumn rainfall may be rightly called "cyclonic rainfall" as distinguished from the "NE monsoon rainfall." These cyclonic rains are far from being continuous, their frequency depending entirely on the frequency of typhoons.

Coronas recognizes four types of rainfall distribution. The first type has two pronounced seasons, dry in winter and autumn. The second type has no dry season with pronounced maximum in winter. The third type is characterized by no very pronounced maximum rain period and by a short dry season, from one to three months in length, while the fourth type has no maximum rain period and no dry season. Baguio has the marked characters of the first type, as fig. 4 shows clearly.

The great variation in the amount of the annual rainfall in Baguio is shown graphically by fig. 5, from the Census.[13] Even

[12] Op. cit. 342. [13] Op. cit. 355.

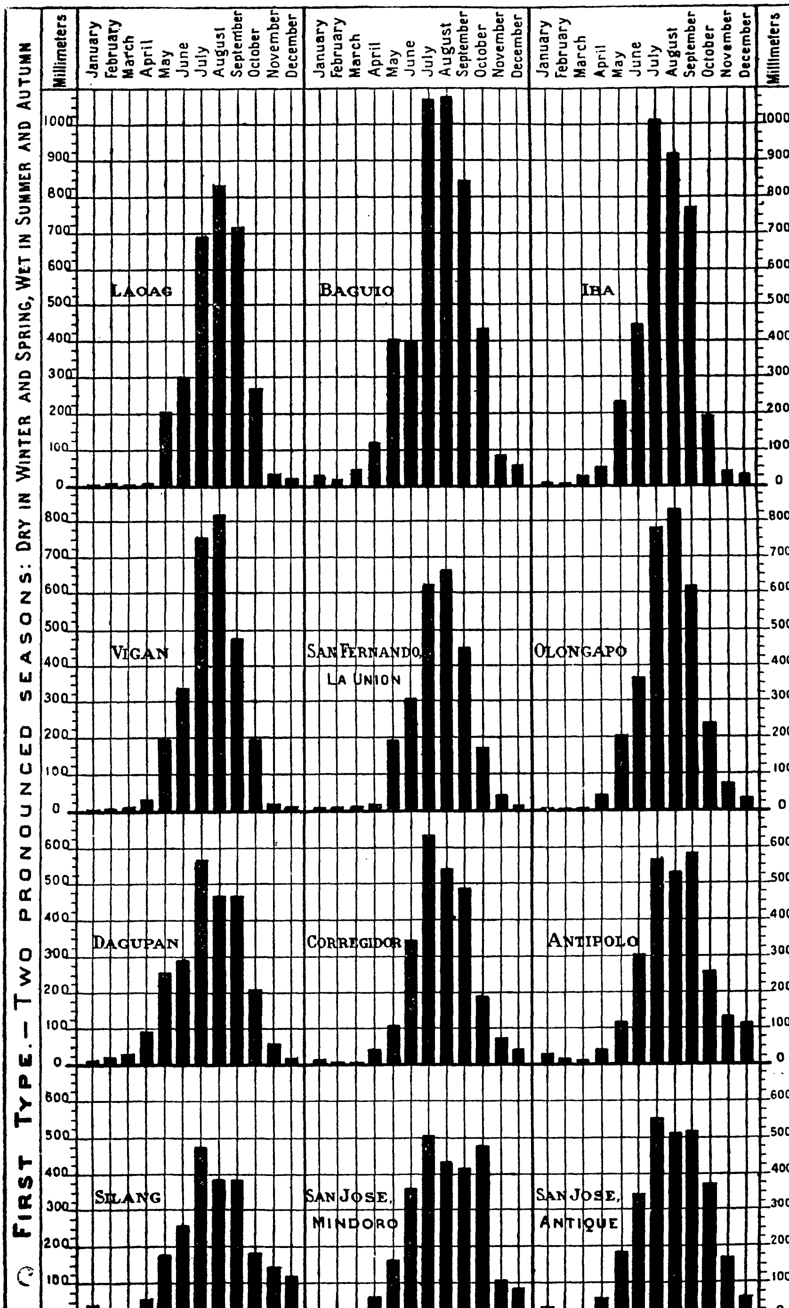


FIG. 4. First type of monthly distribution of rainfall in the Philippines; two pronounced seasons.

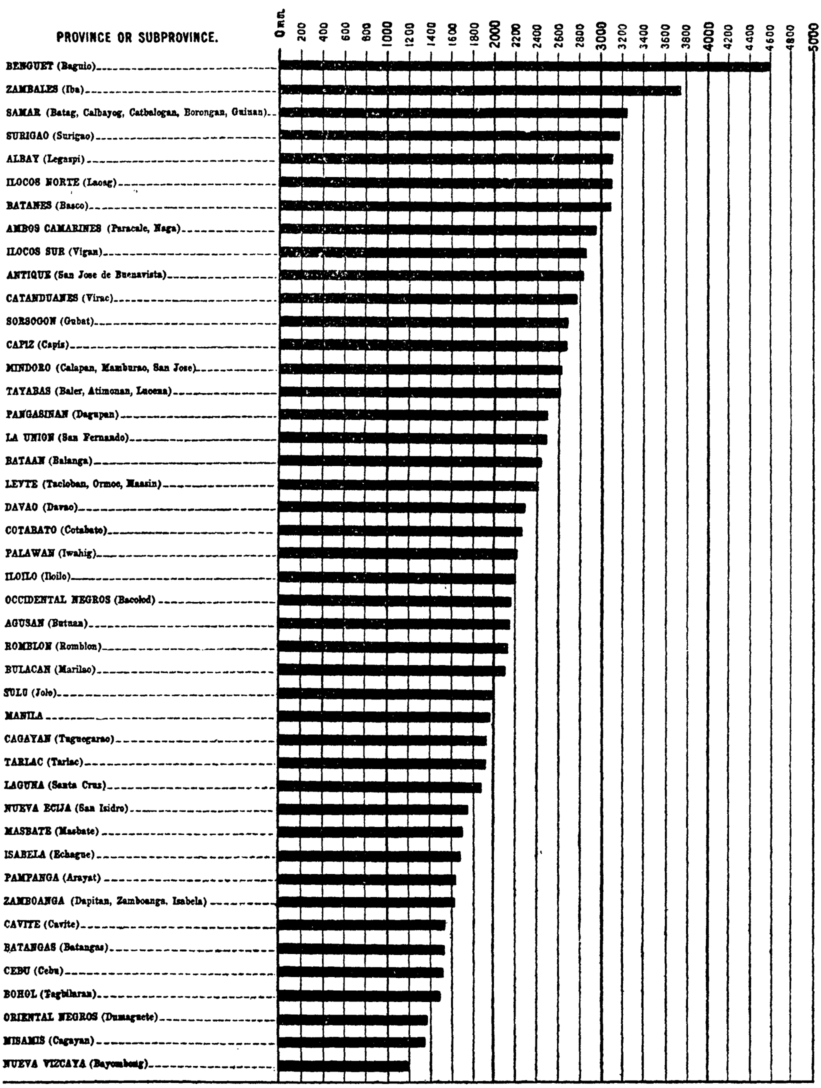


FIG. 5. Average annual rainfall of provinces and subprovinces.

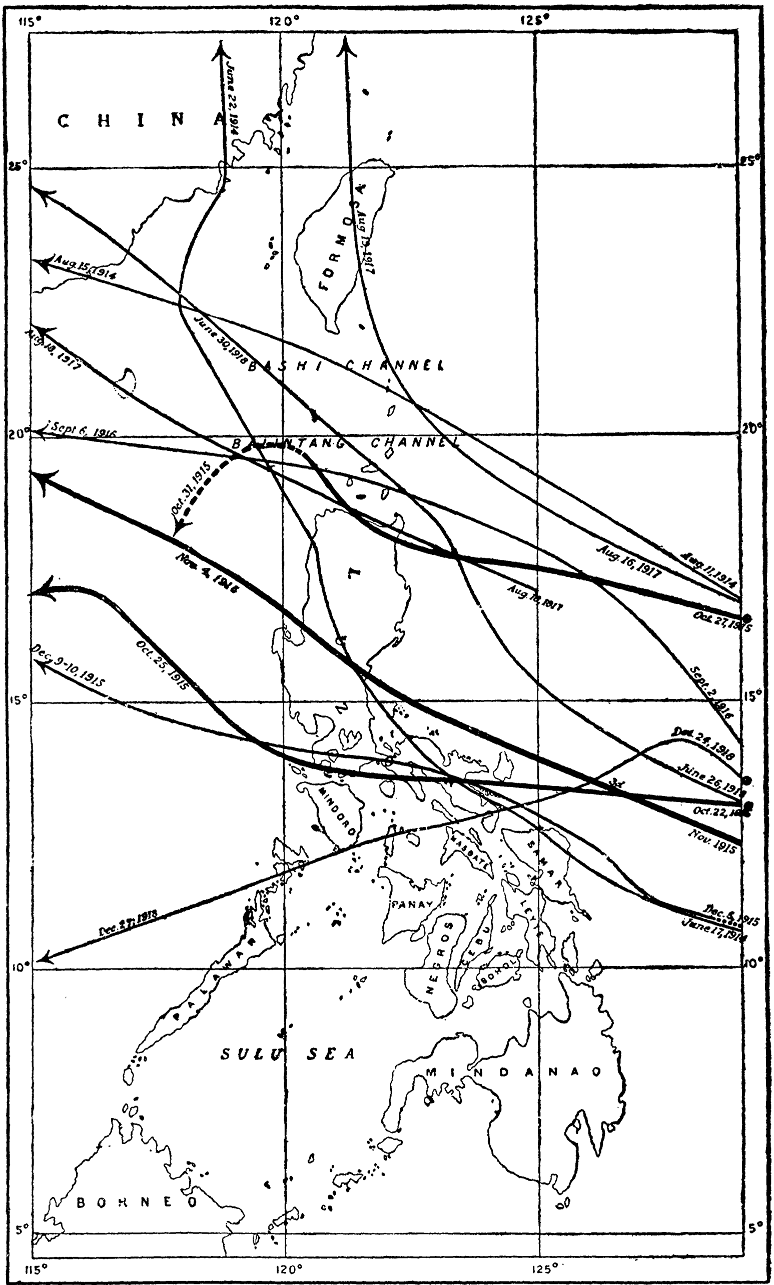
with the great record of 9,038.3 millimeters (355.84 inches) made in Baguio in 1911, this station is greatly exceeded by that of Cherrapunji, Khasi Hills, India, whose average annual rainfall is 10,820 millimeters (426 inches), and by Mount Waialeale Station, Kauai Island, Hawaiian Islands, which reports 561 inches rainfall from May 21, 1915, to May 30, 1916.

However, as pointed out in the introduction, the torrential character of the rainfall, taken together with a great annual precipitation, is the chief concern of the geologist in considering the problem of the rate of development of land forms. The world's record for this characteristic is claimed by Baguio. Coronas described this event as follows:[14]

> As to Baguio, the absolute maximum rainfall observed in a single day is as great as 879.8 mm., an amount which is above the annual average rainfall of many cities of Europe and of the United States. This heavy rain occurred during a typhoon which crossed the northern part of Luzon on July 14 to 15, 1911. No less than 2,238.7 mm. of water were collected by the rain gauges of Baguio in four days, as follows: July 14, 879.8 mm.; July 15, 733.6 mm.; July 16, 424.9 mm.; and July 17, 200.4 mm. These daily amounts of rain are counted as it is customary in the Philippines from 6 a. m. of one day to 6 a. m. of the next day. But the most remarkable thing is that taking only the period of hours in which the rains fell with most heaviness, we have the incredible amount of 1,168.11 mm. recorded, as shown in a Friez Quadruple Register, in only 24 hours, from noon of the 14th to noon of the 15th.
>
> Although Baguio is not one of the wettest places of the world, yet the record of 1,168.1 mm. in 24 hours is considered, as far as known, a world's rainfall record for a period of 24 consecutive hours.

As was indicated above, the principal controls of climate are the typhoons taken together with the mountainous character of the Philippine Islands. Baguio is centrally situated as respects typhoon tracts, as most Philippine typhoons either pass over Baguio or are sufficiently near, either to the north or to the south, that Baguio is under their influence. This is well shown in fig. 6 which is copied from Coronas's work.[15] That elevation is a factor is shown by comparing graphs for Laoag on the seacoast north of Baguio and for Iba on the south coast, see fig. 5, but even these stations have an enormous rainfall as compared with stations in the United States. If the Baguio region were 900 meters (3,000 feet) lower than to-day its rainfall would even then be quite sufficient to accelerate the processes of erosion. In Pleistocene time these same climatic controls probably prevailed, and the process of the reduction of a high mountainous region to a gently rolling upland which merged into a coastal plain was exceedingly rapid. Likewise, since the uplift of Baguio Plateau, erosion has over large tracts of country completely removed all traces of this early old-age surface.

[14] Op cit. 379. [15] Op. cit. 456.



Very remarkable typhoon with a barometric minimum below 720mm.; —— Remarkable typhoon with a barometric minimum below 742mm.; ⊕ Abnormal track

FIG. 6. Tracks of remarkable typhoons, 1914 to 1918.

SUMMARY

Baguio Plateau is a remnant of an early old-age surface, formed during a portion of Pleistocene time, uplifted to the present elevation of 1,200 to 1,500 meters, and largely eroded during Recent time (Plate 12, fig. 2). Various northern extensions of this peneplain have been recognized at Mount Data and intervening points by Dr. Warren D. Smith. Botanical evidence indicates that in the northern half of Luzon distant mountains with elevations of from 1,050 to 1,500 meters or more were present, and upon these elevations the ancestral stock of the present upland temperate flora was preserved. The vast acceleration of geologic processes in the Tropics is not due to mere quantity of rainfall, but to rainfall delivered as torrential downpours. The irresistible energy of the streams carrying these great volumes of water quickly leveled the mountains of early Pleistocene time over much of the area of the northern half of Luzon and reduced them to gently rolling hills and intervening wide shallow valleys. In late Pleistocene time this surface was uplifted in at least two and probably three stages, as the Amsalsal Plateau and the two terraces encircling Trinidad Valley indicate. Accompanying this uplift, faulting upon a great scale upthrust such masses as Mount Santo Tomas and the high mountain in northern Luzon, Mount Data.

Baguio Plateau cuts across rocks of various ages, diorites of the basement complex, Vigo-Miocene sandstones, Malumbang limestones, and the tuffs and agglomerates of the Baguio formation (Plate 12, fig. 3). This plateau is now in a geologic sense rapidly disappearing, through a process of rapid erosion aided by solution of underlying limestone and slides upon the plateau edge due largely to this sapping action, and owing to these agencies our descendants of a few thousand years hence will not enjoy this charming fairy-land.

ILLUSTRATIONS

PLATE 1

Relief model of Baguio, showing striking contrast between Baguio Plateau and the deeply incised valleys of Bued River, Gold Creek, and Antamok River. (From the model made in the Bureau of Science from the map by A. J. Eveland.)

PLATE 2

Topographic map of Trinidad Valley and vicinity.

PLATE 3

Panorama of Baguio Plateau taken from Mount Mirador looking to the north and east. Naguilian Trail on the left; the rugged limestone hill on the left at the skyline is one of the portals of Trinidad Water Gap. The rounded hills in the background are those of Pacdal. Dominican Monastery, on the right. A small residual of Baguio formation resting unconformably upon Pliocene limestone is seen just beyond the fork of Mount Mirador and Dominican Roads. (Photograph by Father Algué.)

PLATE 4

FIG. 1. Mount Data, showing fault scarp on the east side. (Photograph by W. D. Smith.)
2. Haight's place, Pauai, showing remnant of old erosion surface. (Photograph by W. D. Smith.)
3. "Hanging valley" of old erosion surface near kilometer 81 on trail from Baguio to Mount Data. (Photograph by W. D. Smith.)

PLATE 5

FIG. 1. Westerly dipping Malumbang limestone about 4 kilometers west of Baguio City Hall on the Naguilian Road.
2. Unconformable contact between arkosic Vigo sandstone and the overlying northerly dipping Malumbang-Pliocene limestone. The fragments embedded in the limestone consist of the stems of coral algæ.
3. Detail of coralline limestone showing abundance of stems of coral. East side of Trinidad River, in center of Trinidad Water Gap, south entrance.

PLATE 6

FIG. 1. Klondike's place near camp 1. Pliocene corals were collected from conglomerate strata at the end of the bridge. A small *Pecten* sp. was found in the sandy matrix of the conglomerate 10 meters from the house toward the left of the picture.
2. Baguio from Pacdal, showing the sharp contrast between the Santo Tomas fault block and Baguio Plateau.

FIG. 3. Mount Santo Tomas in the background; characteristic slide topography on the southwestern edge of Baguio Plateau. From a point near Government Center.

PLATE 7

The Zigzag on Benguet Road. Bued River Cañon on the right.

PLATE 8

FIG. 1. Bued River Valley. (Photograph by A. J. Eveland.)
2. Baguio Hospital, on the outer edge of Baguio Plateau. At the extreme left, slices of the Baguio formation are being slipped off from season to season. Mount Santo Tomas is the highest peak in the background.

PLATE 9

FIG. 1. Loacan Valley, showing present small stream occupying the exceedingly wide shallow valley. Mount Santo Tomas in the background.
2. Baguio City in 1905. (Photograph by A. J. Eveland.)

PLATE 10

FIG. 1. Flora from Baguio tuffs near Government center. *Clethra lancifolia* (Turcz.).
2. Loacan Valley from Mount Santo Tomas Trail.
3. North-dipping coralline limestone beds, east side of Trinidad Valley, and compact andesitic tuff-breccia of the Baguio formation. The low gap marks the location of a prominent fault between the above-mentioned beds.

PLATE 11

FIG. 1. Close view of Trinidad Water Gap, looking south from the provincial capitol. Marshy area in the foreground, Pacdal Hills in the background.
2. North-dipping limestone on east side of Trinidad Valley. Fault between this limestone and hard resistant andesitic breccia of the Baguio formation is marked by the low gap in the center. This low gap is not the exit of Trinidad River, but this gap was formed long after Trinidad River was intrenched in its north water gap which lies between the rounded hills on the left and the hill slope on the extreme left. One bowlder eroded from Malumbang coralline limestone was found near the top of the rounded hill on the left, and other fragments were found on the hill slope about the extreme left edge of this picture. Definite stream gravels occurred slightly to the left beyond the picture.
3. Looking south across Trinidad Valley, Trinidad farm school buildings in the left center. A 4,850-foot terrace on the left; hills around Baguio seen beyond Trinidad Water Gap. Hills on the right consist of Malumbang limestone.

PLATE 12

FIG. 1. View of the western and southern side of Trinidad Valley, illustrating the difference in character of hill forms in the coralline limestone on the left and the soft Baguio tuffs on the right. The marshy area marking a portion of the old ox-bow course of Trinidad River is located just beyond the provincial capitol.

2. Amsalsal Plateau from the east side of North Trinidad Valley Water Gap. A correlative of this plateau is dimly outlined on the right. This plateau probably represents a substage in the development of Baguio Plateau.

3. Mount Mirador, illustrating the rugged character of the Malumbang coralline limestone.

TEXT FIGURES

FIG. 1. Sketch map showing Baguio and a portion of central Luzon.

2. Sketch map of Mount Data, Mountain Province, Luzon. (By Warren D. Smith, 1922.)

3. Geologic sketch map of Baguio and vicinity.

4. First type of monthly distribution of rainfall in the Philippines; two pronounced seasons. [After Coronas in Census of the Philippine Islands 1 (1920) 349.]

5. Average annual rainfall of provinces and subprovinces. [After Coronas in Census of the Philippine Islands 1 (1920) 355.]

6. Tracks of remarkable typhoons, 1914 to 1918. [After Coronas in Census of the Philippine Islands 1 (1920) 456.]

PLATE 1. RELIEF MODEL OF BAGUIO. IN THE HORIZONTAL SCALE 1 CENTIMETER EQUALS ABOUT 565 METERS.

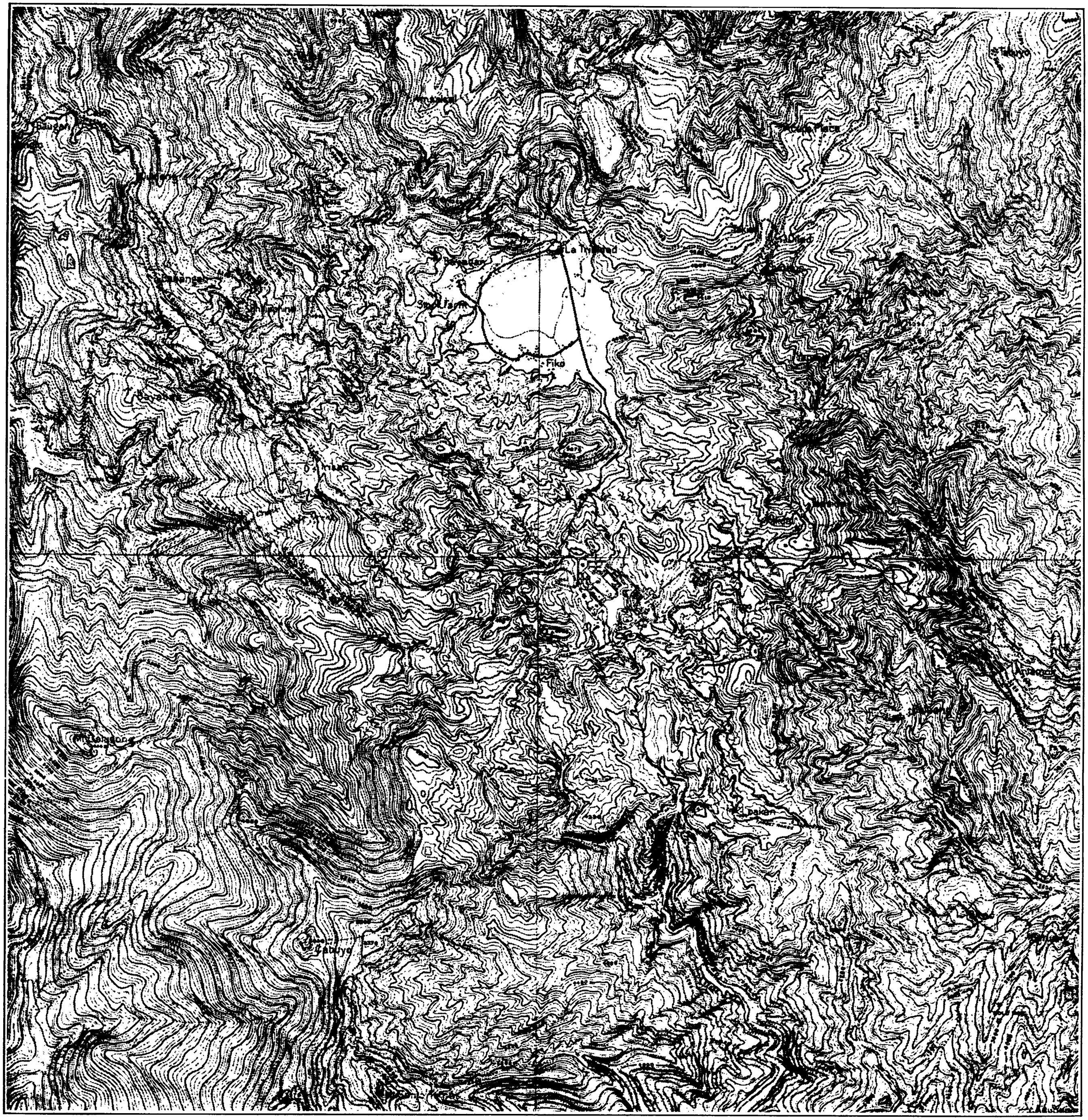
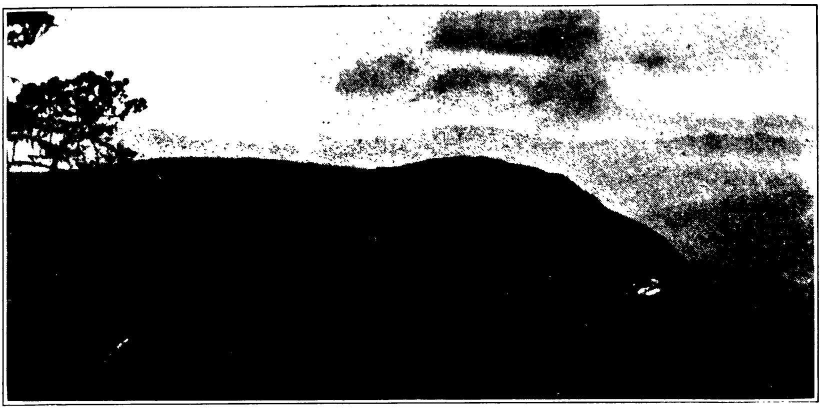


PLATE 2. TOPOGRAPHIC MAP OF TRINIDAD VALLEY.

PLATE 3. PANORAMA OF BAGUIO PLATEAU TAKEN FROM MOUNT MIRADOR.



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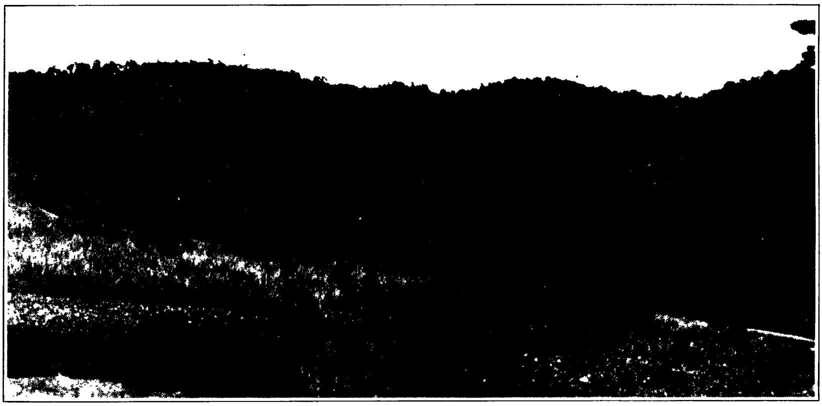

Fig. 2. Haight's place, Pauai, showing remnant of old erosion surface.

Fig. 3. Showing "hanging valley" of old erosion surface near kilometer 81 on trail from Baguio to Mount Data.

PLATE 4.

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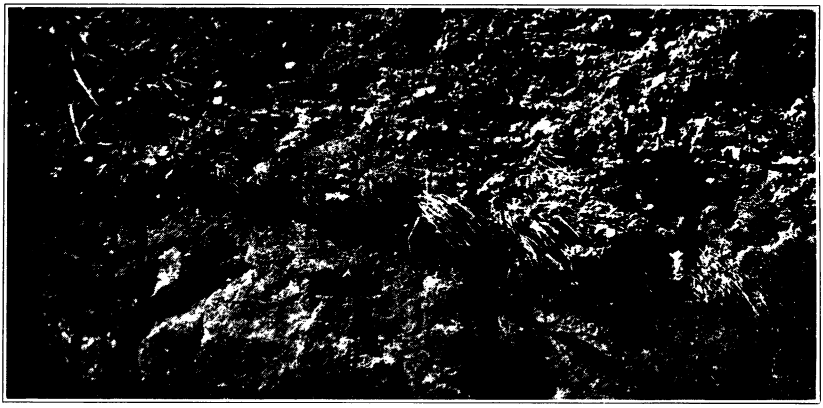


Fig. 2. Uncomformable contact between arkosic Vigo sandstone and the overlying northerly dipping Malumbang.

Fig. 3. Detail of coralline limestone, showing abundance of stems of coral.

PLATE 5.

Fig. 1. Klondike's place near camp 1.

Fig. 2. Baguio from Pacdal.

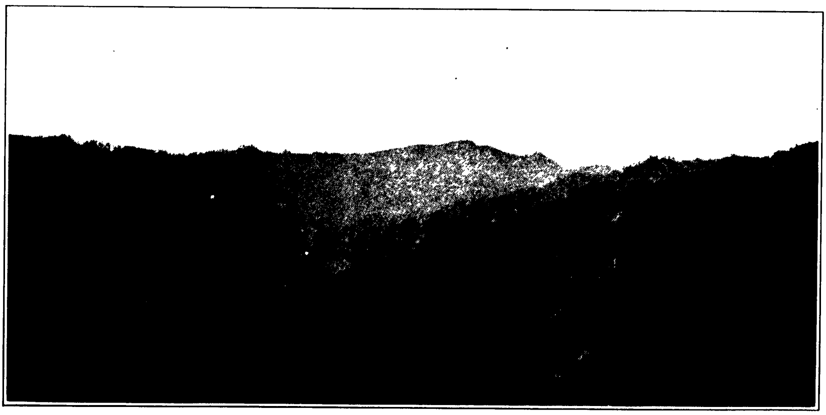


Fig. 3. Characteristic slide topography on the southwestern edge of Baguio Plateau.

PLATE 6.

PLATE 7. THE ZIGZAG ON BENGUET ROAD. BUED RIVER CAÑON ON THE RIGHT.

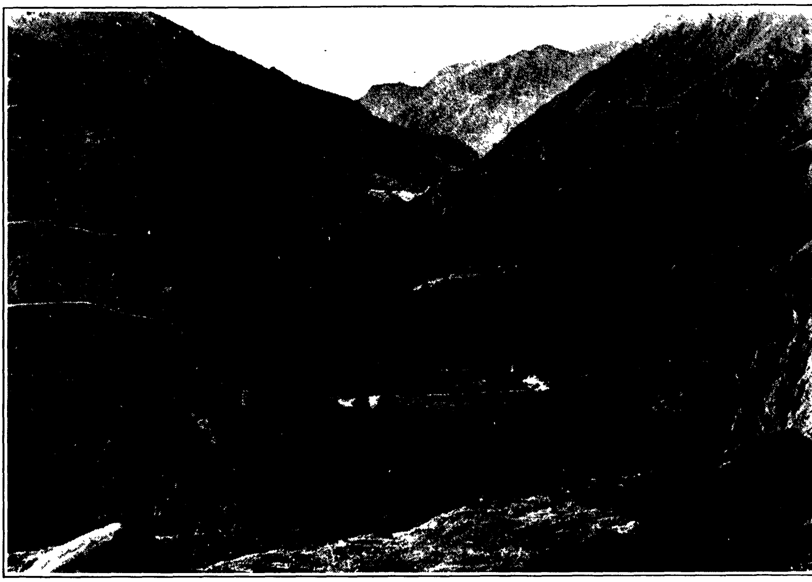


Fig. 1. Bued River Valley.

Fig. 2. Baguio Hospital, on the outer edge of Baguio Plateau.

PLATE 8.

Fig. 1. Loacan Valley, showing present small stream occupying the exceedingly wide shallow valley.

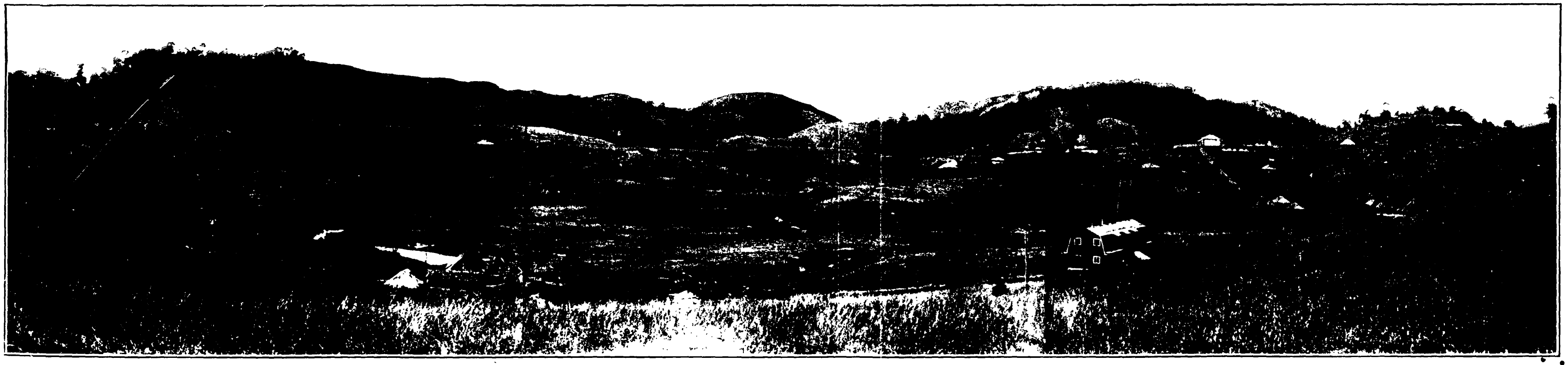
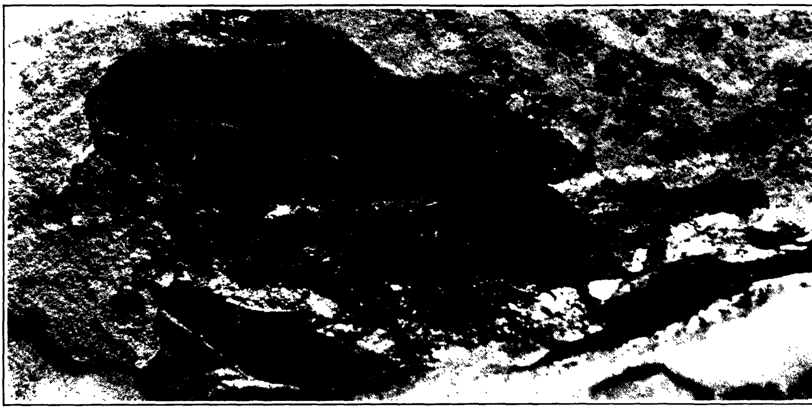


Fig. 2. Baguio City in 1905.

PLATE 9.



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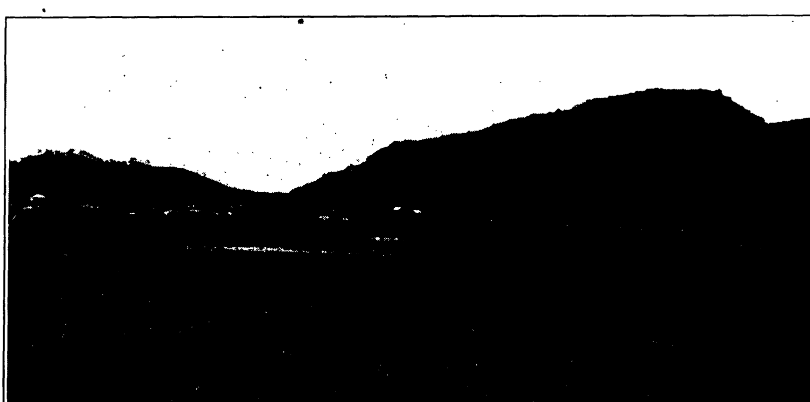


Fig. 3. North-dipping coralline limestone beds, east side of Trinidad Valley.

PLATE 10.

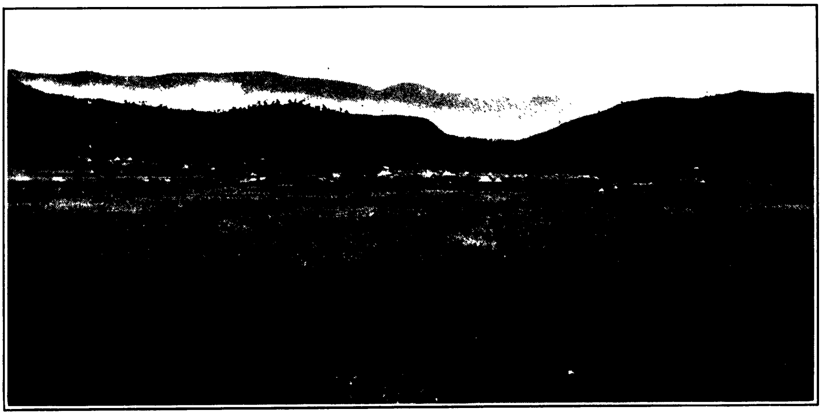
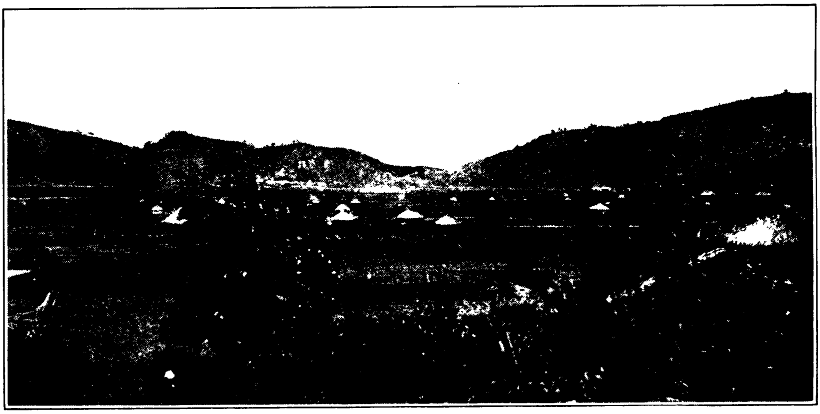


Fig. 1. Close view of Trinidad Water Gap, looking south from provincial capitol.



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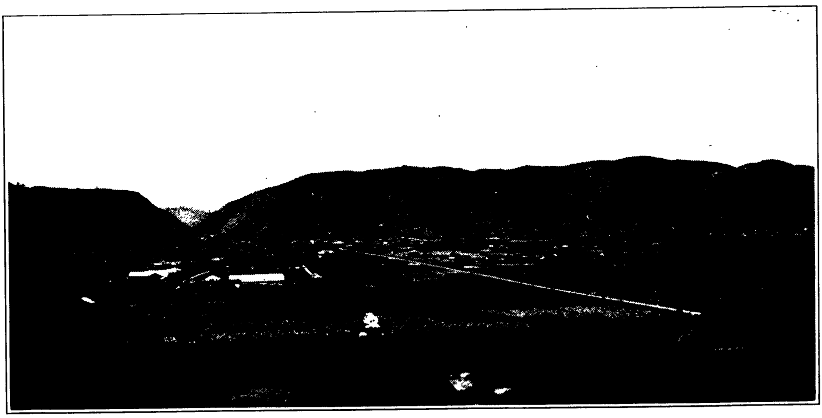
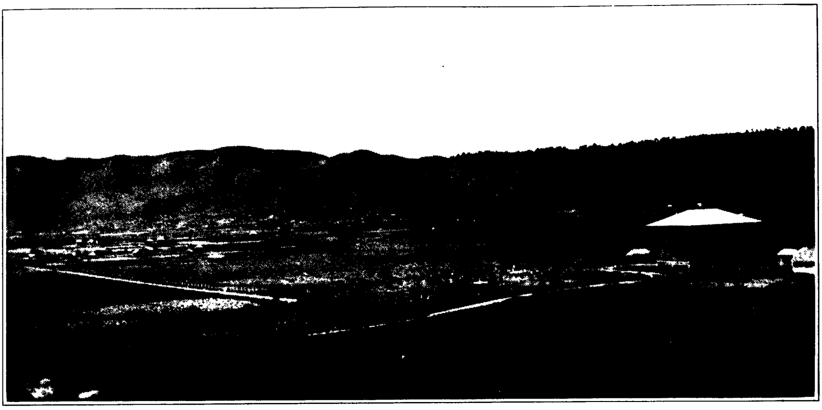


Fig. 3. Looking south across Trinidad Valley.

PLATE 11.



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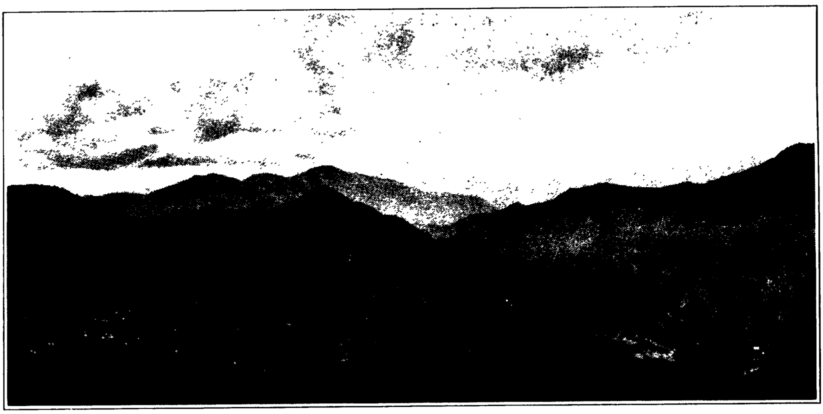

Fig. 2. Amsalsal Plateau from the east side of North Trinidad Valley Water Gap.

Fig. 3. Mount Mirador, illustrating the rugged character of the Malumbang coralline limestone.

PLATE 12.

THE TREATMENT OF HOOKWORM INFESTATION WITH CARBON TETRACHLORIDE

A CLINICAL AND LABORATORY STUDY

By CHARLES N. LEACH
Of the International Health Board

FRANK G. HAUGHWOUT
Of the Bureau of Science, Manila

and

J. EARLE ASH
Major, Medical Corps, United States Army

ONE PLATE

INTRODUCTION

The work that forms the basis of this report was first undertaken early in May, 1922, at a time when reports of a more or less contradictory nature concerning the safety of carbon tetrachloride in the treatment of hookworm infestations in man were being published from various parts of the world. Most of these reports constituted the products of field work, by men who had neither the opportunity nor the facilities for detailed study, so we reached the conclusion that the time had arrived for making a start toward the promulgation of a more precise knowledge concerning the action of the drug. We early gained the impression that many of the accidents that had occurred might be traced to the use of an impure drug, so we determined to study the action of the pure drug in as much detail as possible. The opportunity for doing this presented itself in Bilibid Prison, in Manila, which has been the scene of many notable studies in experimental medicine. The project was rendered the more feasible by reason of the amiability with which the average Filipino submits himself to reasonable experimentation. We desire to record our appreciation of the willingness with which our volunteer subjects entered into the work.

Most of all, however, must we record our gratitude to Dr. Henry Pick, chief of the prison sanitation division of the Phil-

ippine Health Service and resident physician and surgeon at the prison hospital, who really made it possible to carry out the study successfully. Doctor Pick placed his hospital, laboratory, and quarantine shed completely at our disposal, furnished us with efficient attendants, and assisted us in many other ways. We also must record our appreciation of the aid given us from time to time by Mr. Philip Jones, chief inspector of the prison, who facilitated our movements in the prison as a whole. In addition to those specifically mentioned in various parts of the paper, we desire to thank Maj. Harry A. Oliver and Capt. R. C. Kirkwood of the United States Army Medical Corps, and Dr. Hilario G. Lara of the Philippine Health Service, who gave us incidental aid at times when one or another of us was temporarily called to other duties.

At the time the work was started we planned to make a study of the elimination of the drug and had invited Mr. Albert H. Wells, chief of the division of organic chemistry of the Bureau of Science, to join us. Pressure of other work, however, prevented us from carrying out this plan, which has been deferred to a later date.

We have reported on this work, which represents observations on one hundred men, in considerable length, because we do not by any means consider that we have said the last word on any of the themes we have discussed. We think it wise, therefore, to give our findings in some detail in order that they may be available to other workers who may desire to check or criticise our report.

It is now apparent that carbon tetrachloride as an anthelmintic against hookworm possesses virtues that can be claimed by no other drug of which we have knowledge; while we believe it is safer than other drugs employed for the same purpose, we feel that much remains to be added to our knowledge concerning its pharmacology, and the extent and duration of pathological effects it may sometimes bring about. Nevertheless, we feel constrained to say that the trepidation we felt in the beginning concerning the administration of the drug has been stilled as a result of our observations. We still recall the half-hesitation, in the face of adverse reports from other places, with which we administered our first doses of 10 cubic centimeters, to three condemned men. Since then we have felt no anxiety in administering 12.5 and even 15 cubic centimeters, in selected cases.

So far as concerns the toxicity of the drug we find ourselves able, at the conclusion of the work, to state that not only did

we have no deaths, but also that in no case treated under our supervision have symptoms of intoxication developed that called for treatment or that gave us the slightest anxiety. We have felt such confidence in our results that we have not hesitated to treat many thousands of cases elsewhere in the Philippines on precisely the same dose standards we employed with these men. So far, there have been no accidents.

MATERIAL AND METHODS

In undertaking this study we laid down two basic principles with respect to the employment of the drug. In the first place, we determined to administer no carbon tetrachloride the purity of which was subject to the slightest question. To that end every lot of the drug that was used was purchased as a pure product from a drug house of established reputation. Before use, it was tested for impurities under the direction of Mr. Wells. We take pleasure at this time, in extending our thanks to Mr. Wells for his interest and coöperation.

We think it opportune at this time to repeat the warning contained in a memorandum kindly prepared for us by Mr. Wells, in response to our request for information concerning the chemical problems involved in the issuance of carbon tetrachloride designed to be administered to human beings. We deem this necessary because we have records of not less than three fatalities in the Philippines that appear to be associated with the administration of an impure drug. Unfortunately we could secure only the barest details of these cases. We were informed that the drug was purchased from a Manila pharmacy and was sent to the user in a soda water bottle labeled "Carbon Tetrachloride, C. P.," and was administered in good faith. Death in these cases seems to have followed the development of symptoms highly suggestive of drug intoxication. Mr. Wells has written us as follows, under date of March 31, 1923:

> Carbon tetrachloride received by the Bureau of Science and often marked "c. p." contains carbon disulphide, aldehydes, and traces of chlorides and sulphur. A recent shipment of 1,000 liters contained an excessive amount of carbon disulphide.
>
> The usual procedure for purification of this product depends upon the impurities present but in full is as follows:
>
> The carbon tetrachloride is refluxed with an oxidizing solution of sulphuric acid and potassium dichromate, distilled off, treated with 15 per cent sodium or potassium hydroxide solution with agitation, separated, washed with water, dried with calcium chloride, and carefully redistilled in glass.

The physical condition of every subject was carefully ascertained by physical and laboratory examination. This enabled us to guard against possible physical contraindications to the treatment, and also gave us a check on the action of the drug under various conditions of pathology in the subject.

The subjects were picked from long-term prisoners, just arrived at the prison. The examinations and treatment were carried out during their term of detention in the quarantine sheds. The men were constantly under the supervision of a trained attendant, so that they were under observation during the entire period of examination and treatment. In all instances where stools were lost or there was any suspicion that anything had occurred essentially to mar the continuity of the record, the case was thrown out and another substituted for it.

In order that the data might be considered uniformly, all the information was placed on individual protocols, the entire record of each case being contained on one sheet as follows:

CARBON TETRACHLORIDE SERIES; BILIBID PRISON, 1922

Prison No ----------------	Exp. No ----------------
Name ----------------	Age ---------- years.
Residence ----------------	Nationality ----------------
Social state, M. S. W. ----------------	Occupation ----------------
Sentence expires ----------------	----------------

LABORATORY DATA

FÆCES.	Helminths.	Protozoa.	Miscellaneous.
	----------	----------	----------
	----------	----------	----------
	----------	----------	----------
	----------	----------	----------

Remarks:--

BLOOD.	Before.	---- hours after.	2 weeks after.
Total R. B. C------	----------	----------	----------
Total W. B. C ------	----------	----------	----------
Hæmoglobin------	----------	----------	----------
Color index ------	----------	----------	----------
Poly neutros------	----------	----------	----------
Poly eosinos ------	----------	----------	----------
Small lymphos------	----------	----------	----------
Large monos ------	----------	----------	----------
Mast cells ------	----------	----------	----------
----------	----------	----------	----------
Anisocytosis------	----------	----------	----------
Poikilocytosis------	----------	----------	----------
Normoblasts------	----------	----------	----------

LABORATORY DATA—Continued

Urine.	----- before.		----- after.
Quantity--------	Albumin --------	Quantity--------	Albumin --------
Color -----------	Crystals --------	Color -----------	Crystals --------
Odor -----------	Casts -----------	Odor -----------	Casts -----------
Reaction--------	Cells -----------	Reaction--------	Cells -----------
Sp. grav--------	Sugar ----------	Sp. grav--------	Sugar ----------

PHYSICAL EXAMINATION AND TREATMENT

Date .... 1922. Examiner ....

Weight { Before treatment .... kgm.
After treatment .... kgm.

Narcotics ....

Family history ....

....

Previous personal history ....

....

Special senses .... Skin and mucous membrane ....

Glandular system .... Vascular system ....

Blood pressure { Before treatment, D .... S ....
During treatment, D .... S ....

Heart .... Lungs ....

G. U .... Nervous system ....

Muscles and joints .... Osseous system ....

Abdomen:

Spleen ....

Liver ....

Tenderness ....

Masses ....

Date .... 1922. Dose .... cc. How given ....

Reaction of patient to drug ....

....

First bowel movement .... hours after treatment.

Worm count.	1st day.		2d day.		3d day.		Total.
	♂	♀	♂	♀	♂	♀	
A. duodenale ----------	-----	-----	-----	-----	-----	-----	--------
Necator ----------	-----	-----	-----	-----	-----	-----	--------
Ascaris ----------	-----	-----	-----	-----	-----	-----	--------
Trichuris ----------	-----	-----	-----	-----	-----	-----	--------
Oxyuris ----------	-----	-----	-----	-----	-----	-----	--------
Tænia ----------	-----	-----	-----	-----	-----	-----	--------
----------	-----	-----	-----	-----	-----	-----	--------

Although this form is self-explanatory, a few words concerning the laboratory methods employed are not out of place. The fæces examinations were made with great care in order to

detect and treat as many types of parasitic infestation as possible, and to discover the light as well as the massive infections. The protozoan findings are subject to the usual error arising from a limited number of examinations and, as the majority of the subjects were microscopically examined only once before treatment, no numerical value can be placed upon them.

Cover-glass preparations were made from each stool, and a sample was concentrated by the Cropper and Row ether-centrifuge method. In the entire group of subjects, there were only two who yielded hookworms on screening, the ova of which were not found before treatment. These two subjects yielded one and seven worms, respectively, on screening.

On the other hand, several exceedingly light infestations were detected microscopically, as is shown on surveying the cases from which ten worms or less were recovered on screening. These cases are recorded in Table 1.

TABLE 1.—*Subjects harboring ten hookworms or less.*

Subjects.	Worms recovered.
2	1
7	2
1	3
2	4
1	5
1	6
4	7
1	8
6	9
1	10

Examinations of the blood and urine were made by the usual methods. Hæmoglobin estimations were made with the Tallquist scale. None of this work was intrusted to laboratory technicians. Blood pressures were recorded with the Tycos apparatus.

A separate cell house was set aside for the accommodation of the men under treatment, and as soon as the drug was administered the water-closets were sealed to avoid loss of stools. Each man was furnished with a separate "jerry" which was marked with his number and name, and an attendant was told off to see that each man used his own receptacle.

On the night before treatment the men were given soft diet. This was done principally to lighten the work of screening the stools. Breakfast and luncheon were withheld and the drug

was administered in twice its volume of cold water at about 1.30 o'clock in the afternoon, the men being immediately marched into the cell house and made to lie down until the bowels began to move. One or more of the authors remained to watch the men and to take and record the pulse and blood pressure of each man one hour after treatment. Such of the men as cared to do so were allowed to eat their evening meal at about 5 o'clock. Stools were collected for three days and carefully screened to recover the worms, after which the men were released from quarantine.

The stools were washed through a screen of sixty meshes to the inch. This probably was finer than necessary, but it was the only screen available in Manila. The worms were preserved in 70 per cent alcohol and later cleared in 10 per cent glycerine-alcohol.

Reëxaminations of the blood and the urine were made twenty-four hours after treatment, and in a considerable number of the cases the blood was examined a third time. Eventually, the stool of each man was examined microscopically to determine if he had been rid of his worms.

Several men in the series were later deported and some others were transferred to a penal colony, so it was not possible to carry out a series of test treatments.

HELMINTHAL FINDINGS BEFORE TREATMENT

While it was desired principally to study the effects of carbon tetrachloride on hookworm infestation, it was thought wise to include a few subjects in which that parasite was not present. Of the men selected for experiment eighty-nine were found, on microscopical study, to harbor hookworms. The remaining eleven were infested with *Ascaris*, *Trichuris*, or both. Infestations with *Ascaris* to the number of fifty-three, and with *Trichuris* to the number of eighty-four, were found in the group. These infestations were distributed as shown in Table 2.

TABLE 2—*Distribution of helminthal infestations.*

Parasite.	Subjects infested.
Trichuris only	6
Ascaris and *Trichuris*	4
Hookworm only	9
Hookworm and *Ascaris*	6
Hookworm and *Trichuris*	31
Hookworm, *Ascaris*, and *Trichuris*	43
Oxyuris	1

PROTOZOAN INFESTATIONS

It was not anticipated that the drug would have any permanent effect on the intestinal Protozoa, with the possible exception of *Giardia*. Only four infections with *Giardia* were detected in the entire series, and we secured no evidence that any of these were affected in the slightest degree. Having in mind the error that obtains with respect to intestinal protozoan findings under a limited number of examinations, we feel justified in stating that carbon tetrachloride is without effect on any of the Protozoa detected by us during this study. We record our data in Table 3, for the purpose of making our record complete, and shall not make further allusion to the action of the drug on the intestinal Protozoa.

TABLE 3.—*Intestinal Protozoa found before and after treatment.*

Species.	Positive cases.		
	On first examination only.	On second examination only.	On both examinations.
Entamœba histolytica	2	5	1
Entamœba coli	5	18	15
Endolimax nana	3	1	0
Iodamœba butschlii	0	0	1
Trichomonas	4	0	0
Chilomastix	1	0	0
Giardia	0	2	2
Enteromonas	1	0	0
Embadomonas	1	0	0
Entamœba (undetermined)	1	1	0

STANDARDIZATION OF THE TREATMENT

Treatment of the men in this series was not started until we had carried out some observations on a group of three murderers condemned to death.[1] At the time, it was contemplated

[1] The observations on these three men were made by two of us, Leach and Haughwout, and do not form part of the work embraced in this report. Major George R. Callender, M. C., U. S. A., president of the U. S. Army Medical Department Research Board for the Philippine Islands, kindly studied the histological preparations and rendered the report we have incorporated here. The necropsy was performed and a report on it furnished to us by Captain Charles H. Manlove, M. C., U. S. A., whose experience in the pathological anatomy of Filipinos has been very extended. We extend our gratitude to these two gentlemen for the valuable assistance and counsel they have given us.

that these men would shortly become available for further investigation on the autopsy table, but the sentences of two were commuted to life imprisonment twenty-four hours before the time set for their execution; therefore, we secured a necropsy of only one man. Each man received 10 cubic centimeters of the drug three days before the date of the execution. The dose was arbitrarily fixed, and was 2 cubic centimeters below the maximum given by Leach to a man in Ceylon.(7) None of the men showed any marked reaction to the drug aside from headache and anorexia.

None of these men was heavily infested. Prisoner 18090 (the man who was executed), harbored 11 hookworms, only 1 of which was an ancylostome. The other two men, Nos. 18093 and 18095, harbored 12 and 42 hookworms, respectively.

The physical examination of prisoner 18090, was made just twenty-four hours prior to his execution, immediately after the death warrant had been read to him. The examination disclosed no physical abnormalities except some anæmia of the mucous membranes. The pulse was regular in rate and rhythm, 82 beats to the minute. Neither the spleen nor the liver was palpable.

The man was hanged at 11 a. m., and the body was delivered to us at 11.30. The thorax and abdomen were opened at 11.35. Captain Manlove's protocol is as follows:

External examination shows the body to be that of a well-developed, well-nourished adult Filipino male. The skin over the thorax is covered with tattoo marks. No pigmentation. There is marked crepitation of the vertebræ of the cervical region. On section of the body there is a normal amount of subcutaneous fat. The muscle is reddish and appears normal.

Abdomen.—The serosa covering the small intestine is pinkish, moist, and apparently normal. The abdominal viscera are normally placed. The diaphragm is normally placed.

Thorax.—The lungs completely fill the thoracic cavity. There are a few adhesions in the right upper thoracic cavity; otherwise the pleural sacs are normal. The lungs, themselves, are considerably distended with air and collapse on section. The lung tissue is apparently normal.

Heart.—The pericardial sac is normal. The heart is about normal in size. The right side of the heart, however, is distended with blood. The muscle is congested but apparently normal.

Spleen.—About normal in size, shape, and consistence. On section considerable blood oozes from the cut surface, but otherwise it apparently is normal. The adrenals are normal in appearance, though slightly congested.

Kidneys.—The kidneys are normal in size, shape, and consistence, but are markedly congested. Otherwise they are normal.

Liver.—It shows marked congestion, but otherwise is normal.

GASTROINTESTINAL TRACT

Duodenum.—There is a slight hæmorrhagic area near the pyloric portion. Particles of undigested food are present; also mucus. Otherwise it is quite normal, and no worms are found. Contents of duodenum screened.

The intestinal tract was removed after first tying the duodenum at the pyloric end of the stomach, then at the extremity of the duodenum, and then tying off the jejunum at its extremities. The ileum, likewise, was tied off at its extremities. The ascending colon at the hepatic flexure was tied off and the transverse colon and descending colon were also tied off. These segments were then dissected out separately. The segments of intestine were then opened lengthwise over a receptacle, and their contents thoroughly washed out into a sixty-mesh-to-the-inch screen, washed and searched for worms.

Jejunum.—No parasites were found. The mucosa throughout was apparently normal with the exception of several slightly congested areas near the duodenal portion. Very large amounts of mucus were found in the jejunum. There also was a considerable amount of partially digested food.

Ileum.—The ileum contained a considerable amount of partially digested food and a large amount of mucus. The mucosa appeared normal. No worms were found.

Color.—Mucus membrane is normal. Contents consist of small amount of formed fæcal material. No parasites found.

It may be remarked in connection with the above, that the viscera are characteristically congested in subjects who have been executed by hanging.

As soon as the abdomen was opened, the kidneys and liver were removed and thin blocks cut from each and immediately fixed. Most of them were fixed in Zenker's fluid, but some also were fixed in Bouin's picro-aceto-formol fluid. Sections were cut 5 μ thick and stained with hæmatoxylin and eosin. Some of these were then submitted to Major Callender, who gave them very careful study. His report to us is as follows:

Sections of liver and kidney of adult male Filipino, executed by hanging, three days after taking 10 cubic centimeters of carbon tetrachloride. Tissues fixed in Zenker thirty-five minutes after death. Stained with Delafield's hæmatoxylin and eosin.

Sections of liver and kidney.—Fixation excellent.

Liver.—Larger veins distended with blood as are a few of the capillaries in the hepatic vein zones. Liver cells are granular, not swollen, nuclear markings distinct and normal throughout all sections. Many of the portal areas show an infiltration with lymphocytes and plasma cells of varying degree; that is, from a few cells about the vessels to an infiltration filling the greater part of the portal connective tissue. There are a few polynuclears in these areas and scattered in the capillaries and lymph spaces throughout the tissue and there are also a few lymphocytes out in the tissue. There is some proliferation of the epithelium lining the bile ducts without other obvious change. The capsule contains quite a few lymphocytes but not collected in masses.

Impression.—A mild degree of chronic cholangitis of some duration was present in this liver and an acute passive congestion. The latter is shown only in the larger vessels and can be accounted for by the method of death.

Kidney.—Old process. There are a few hyaline masses representing replaced glomeruli and a few of the glomeruli show beginning changes of similar character. There is no change obvious except in and in the vicinity of the glomeruli.

Acute.—There is an engorgement of the veins and glomerular capillaries with blood, some groups being much more intensely affected than others. There has been some absorption of fluid in the epithelium of the glomeruli and of the proximal convoluted tubules, but no change in staining reaction of the nuclei.

Impression.—Slight chronic glomerulo-nephritis. Acute passive congestion due to manner of death.

Photomicrographs of some of the sections studied by Major Callender are shown on Plate 1.

In their paper on the pathologic effects of carbon tetrachloride on the human liver, Docherty and Burgess(2) proceed on the basis afforded by the report of Smillie and Pessoa(9) who state that small doses of carbon tetrachloride produced fatty degeneration of the liver and kidneys in dogs.

Docherty and Burgess's experiments were made on three condemned prisoners in Ceylon. Two of these men received 5 cubic centimeters of the drug in single doses while the third was given a total of 8 cubic centimeters in two doses, the first of 5 cubic centimeters, and the second of 3 cubic centimeters, about two weeks later.

The first man was executed and went to autopsy six days after treatment. Macroscopically the liver showed no evident change. Microscopically there was "no well-defined change." There was no evident macroscopic or microscopic change in the kidney.

The second man was executed two weeks after treatment. Macroscopically, the liver was "slightly friable." Histologic sections of the same organ showed "granular degeneration of liver cells. Leucocytic infiltration." There was no evident macroscopic change, and no definite microscopic change in the kidney.

The third man, who received a total of 8 cubic centimeters of the drug, was executed eighteen days after treatment. Macroscopically, his liver was found to be "very friable." Microscopically, Docherty and Burgess report "Fatty degeneration of liver cells. Diffuse leucocytic infiltration." The kidney in this subject showed no evident change, but microscopically there was "cloudy swelling of proximal tubes."

On the basis of this evidence Docherty and Burgess conclude:

From the above it is quite evident that the anthelmintic, in the quantities mentioned, produced lesions in the liver in two cases, as Smillie anticipated; on this account it seems inadvisable to prescribe even a 5 c.cm. dose with purgation, let alone without it.

We feel compelled to disagree radically with the above conclusion. We are not convinced that the drug produced the lesions described by Docherty and Burgess. Leucocytic infiltration, so far as we are aware, is not produced by drug intoxication. Leucocytic infiltration of the liver is to be seen in a fairly large proportion of natives of the Tropics and is possibly the expression of a more or less inactive infectious process in the intestine. It is to be noted that Major Callender reports it among his observations on one preparation. The only significant thing we can see in Docherty and Burgess's report is the finding recorded as "fatty degeneration of liver cells," but even there evidence is lacking in support of the statement that it was caused by carbon tetrachloride. It appears from the record of this case, however, that this man's bowels did not move for the first twenty-four hours after he took his first dose of 5 cubic centimeters of the drug. The drug was administered at 8 a. m. Two hours later he complained of dizziness and nausea and immediately vomited the cathartic (salts) that had been given him at 4 p. m. The second installment of the treatment apparently gave him no discomfort. We add these facts simply to make the record complete, and not because we believe that the retention of the drug worked the man any real damage. Two men in our own series went for nearly twenty-four hours after treatment without a bowel movement, at the end of which time we gave them salts. They showed no untoward symptoms.

The chemical structure of carbon tetrachloride and chloroform, and what we know of the pharmacology of the two substances, give ground for the belief that their action upon the organism, when absorbed in harmful quantities, may be very similar. The action of chloroform upon the liver is too well known to require discussion here, but a review of the anatomy of this organ makes it clear that the location of lesions in the liver with reference to the anatomical structure has a distinct importance in considering the genesis of liver pathology. The report of Docherty and Burgess states that fatty degeneration was present, but omits a description of the character and location of the lesions, so it is impossible for us to satisfy ourselves that the fatty change was due to carbon tetrachloride and not

to some concomitant condition of another nature, and possibly from a different location. This is not a quibble; it is very germane. In view of the frequent pathology found in tropical livers, we consider this a very important point to determine. Interpretation of such findings should be made with strict attention to the fallacy of concomitant variations.

In our judgment, it will require more complete and convincing evidence than Docherty and Burgess have produced to establish that pure carbon tetrachloride in doses of 5 to 8 cubic centimeters will produce lesions in an adult liver save in very exceptional circumstances or where a disorder of the liver already exists. Another very important desideratum that we feel should be borne in mind in connection with the work of both Smillie and Pessoa, and Docherty and Burgess, is that neither publication contains definite information regarding the grade of purity of the drug used. We are of the opinion that discussions regarding the toxicology of carbon tetrachloride are futile unless they are accompanied by a definite statement regarding the chemical purity of the carbon tetrachloride that was employed in the experiments.

In connection with the above, it should be noted that our subject was necropsied three days after treatment, while Docherty and Burgess's men went to autopsy six days, fourteen days, and eighteen days, respectively, after the drug had been administered.

The foregoing clinical and pathological observations having made it clear to us that our man had sustained the administration of 10 cubic centimeters of carbon tetrachloride without organic damage, and the other men having in the meantime shown no ill effects, we decided to base our future work on the standard afforded by him. The man was a fair physical representative of the men with whom we were to deal. His weight before execution was 54 kilograms, so that simple calculation showed that he had been treated on the basis of 1 cubic centimeter of the drug to each 5.4 kilograms of body weight. We thereupon fixed as a maximum dose-basis for treatment 1 cubic centimeter of carbon tetrachloride to each 5.5 kilograms of body weight.

We consider it unnecessary at this time to review the work of all those who have experimented in the treatment of hookworm infestation with carbon tetrachloride. Few apparently have ventured to administer the drug in the doses we have employed, yet some have reported toxic effects of a grave nature

on the administration of doses as low as 3 cubic centimeters, and not a few have expressed serious doubts regarding the safety of the drug. We never have administered a dose as small as that to any adult, yet in no instance have symptoms developed in our series that have given us the slightest cause for anxiety. In another part of this paper we shall discuss accidents that have happened to persons who were not under our control.

We are of the belief that the use of carbon tetrachloride involves the exercise of the same medical knowledge and judgment as are required in the administration of any other powerful drug. We further believe that most instances in which untoward symptoms supervene may be traced to either impurity of the drug, alcoholism, or disease of the liver. We place these factors in what we believe to be their order of usual occurrence. While we do not criticize the product of any reputable drug manufacturing house, we have from the beginning declined to administer any carbon tetrachloride, no matter from what source, until it has been assayed at the Bureau of Science. The detection of the slightest impurity has invariably led to the redistillation of the drug before its issuance.

We do not wish to be understood as insisting on the administration of carbon-tetrachloride in the comparatively massive doses that we have used. Inspection of our tables will show very clearly that it is quite possible to obtain satisfactory results on a milder basis. Lambert,(6) who has treated 20,000 subjects in Suva, Fiji, reports results that check almost identically with ours as regards the recovery of worms after treatment. He administers 0.2 cubic centimeter of the drug per year of age up to 15 years, giving a uniform dose of 3 cubic centimeters thereafter, irrespective of age or weight. However, on the basis of these and the 25,000 other cases of our own that we cite in this paper, we feel that we have definitely proved that the fears expressed by other workers concerning the toxicity of carbon tetrachloride are largely groundless.

We have selected from our Bilibid group ten men who were successfully treated on a basis of 1 cubic centimeter of the drug to each 5.5 kilograms of body weight, and have arranged them by weight according to our scale, and also by age, in order to show what they would have received from us according to our method and what they would have received by extending Lambert's age-dosage scale beyond 15 years. It will be seen that only one man would have received a dose beyond the

maximum given by us in this series—a man 70 years of age who would have received 14 cubic centimeters, which dose we already have exceeded by 1 cubic centimeter, with a man in another series, without any ill effects. These figures are set forth in Table 4.

TABLE 4.—*Comparative dosages of carbon tetrachloride as determined by body weight and age.*[a]

Prisoner No.—	Weight.	Our scale.				Extension of Lambert's scale.	
		1 cc. to 5.5 kgm.	1 cc. to 6.0 kgm.	1 cc. to 6.5 kgm.	1 cc. to 7.0 kgm.	Age.	0.2 cc. per year.
	kgm.					*Years.*	
13112	50.0	8.7	8.3	7.6	7.1	48	9.6
14641	40.9	7.4	6.8	6.2	5.8	28	5.6
14642	59.5	10.8	9.9	9.1	8.5	26	5.2
14707	52.7	9.5	8.7	8.1	7.5	29	5.8
14708	62.2	11.3	10.3	9.5	8.8	33	6.6
14709	56.8	10.3	9.4	8.7	8.1	21	4.2
14710	61.6	11.2	10.2	9.4	8.8	45	9.0
14711	45.9	8.3	7.6	7.0	6.5	25	5.0
14713	55.0	10.0	9.1	8.4	7.8	38	7.6
19370	48.1	8.7	8.0	7.4	6.8	70	14.0

[a] Of course, it would be irrational to extend Lambert's scale beyond, say, 21 to 25 years. The figures merely are given as a matter of passing interest.

The average dose of carbon tetrachloride administered to all the men in the series was 8.96 cubic centimeters. The extremes were 6.2 cubic centimeters and 12.5 cubic centimeters, the latter dose having been administered to two men.

Relatively few men escaped some reaction to the drug. The usual symptoms (those we have arbitrarily characterized as "normal") consisted of vertigo and drowsiness. The majority of the men passed into a quiet sleep from which it was not especially difficult to rouse them, within fifteen or twenty minutes after they had taken the drug. This sleep rarely lasted more than an hour or two. Usually most of the men in the different squads were awake when their pulses and blood pressures were taken one hour after treatment, but they usually were quite content to lie still for another hour. Some of the men spoke of vague sensations in the abdomen which we are inclined to regard as the expression of rather vigorous peristaltic movements of the intestine.

Bowel movements, as a rule, began about one to two hours after treatment, and the bowels moved several times within the next twenty-four hours. There was a return to normal

consistence of the stool by the end of the first day following treatment. The first bowel movements were not accompanied by any disturbance, but after two to three hours the drug was prone to leave the intestine in one gush, which occasioned great surprise and some momentary discomfort to the patient.

Occasionally, as a departure from what we have styled the "normal," patients would complain of nausea and vomiting, or excessive thirst, or anorexia, or weakness. Exceptionally, there was abdominal pain, or continued vomiting, or both. Vomiting occurred only in subjects who received 8 cubic centimeters of the drug or more. Only two patients became constipated during treatment. They each were given magnesium sulphate the day following treatment and apparently experienced no ill effects from the prolonged retention of the drug.

At this time it seems appropriate to say something concerning the general hepatic and intestinal reaction to the drug as evidenced by the appearance of the bowel contents after treatment. This bears particularly upon the appearance of bile and mucus in the stools. The detailed observations are recorded in Table 10, which must be consulted for information as to the findings in the individual subjects.

As we have shown elsewhere, carbon tetrachloride exerts a definite stimulating influence upon the liver, and markedly increases the volume of bile discharged into the intestine. Its effects as a cholagogue may be apparent up to the third day after treatment, but as a general rule the bile content of the stool tends to return to normal after the first twenty-four hours.

Stools passed after treatment usually are watery after the contents of the lower bowel have been evacuated. The watery fluid is charged with greater or lesser amounts of bile. Usually, this is dark brown in color, but occasionally stools are passed that are of a brilliant green hue and, if mixed with considerable mucus, bear a resemblance to stools passed by young children who are suffering from disorders of the intestinal tract. We have been unable to determine that an excessive bile content to the stool is associated with any particular symptom or train of symptoms in the subject. We have given carbon tetrachloride to one subject who was jaundiced before treatment, and also have administered it in several cases in which there was definite enlargement of the liver (presumably of malarial origin) without noting any symptoms referable to the liver. In no instance has a subject complained of pain or even discomfort

in the region of the liver. None of our subjects has become jaundiced after treatment.

The local effects of the drug upon the intestinal mucosa are often quite marked. They are expressed by the production of variable amounts of mucus and, as in the effects upon the liver, seem to bear no constant relation to the amount of drug given. Even under the lightest doses mucus is present in the stools, in amounts in excess of that encountered in so-called normal stools. From that point, there is every gradation in quantity up to the point where the bowel discharges consist almost wholly of clear, glairy mucus. In some cases the mucus has a flocculent appearance that resembles the pus seen in bacillary dysentery, but microscopic examination shows it to be devoid of an excess of cellular elements. Excessive secretion of mucus bears no constant relation to abdominal pain after treatment.

In another paper(8) we have mentioned the seeming ill effects brought about by administering a saline purgative immediately before treatment. We suspect that this procedure has a tendency to heighten the intestinal irritation produced by the drug. Preliminary purgation is unnecessary, and we advise against its employment immediately before the administration of carbon tetrachloride. Its effect with the drug seems almost synergistic so far as concerns the production of mucus, for the stools consist wholly of thick, tenacious mucus discharged in great volumes. So voluminous and thick is this mucus that it virtually is impossible to screen the stools. If patients are constipated, it is better to clear the bowel over a period of a day or two by milder methods, and allow the intestine to rest for at least eight or ten hours.

In two instances we have observed the passage of a blood clot from the intestine after treatment. The first case was a young American male with a past history of malaria and bacillary dysentery. He was alcoholic and had drunk Scotch whiskey shortly before taking 8 cubic centimeters of carbon tetrachloride. He slept soundly for about two hours. When he awoke his speech was thick and rambling. In other words he behaved like a man intoxicated with alcohol. He did not feel sick in any way. He was a young man of considerable braggadocio and bravado and immediately consumed a hearty meal of tea and toast, fortunately escaping consequences of this unwise act. Within a few hours he had resumed his normal habits as to alcohol and, except for looseness of the bowels, got along very well until the seventh day, when he passed a small blood

clot. This he brought into the laboratory where it was found to consist entirely of blood. The passage of this clot was not accompanied by any recognizable symptoms, and nothing further developed. It was his third treatment for hookworm infestation, the other two having been carried out with chenopodium, which failed to clear him.

The second case occurred in this series and, of course, was in a Filipino subject. He received 11.7 cubic centimeters of

TABLE 5.—*Reactions of subjects who gave a history of acute or chronic intestinal affections.*

Prisoner No.—	Dose of carbon tetrachloride.	Past intestinal history.	Stool findings after treatment.			General reaction to drug.
			Bile.	Mucus.	Blood.	
	cc.					
13112	8.7	Diarrhœa	—	—	—	Vomited.
14646	7.5	Dysentery for two years	—	—	—	Do.
19189	6.9	do	+	+	—	Normal.
56471	7.7	*Entamœba histolytica* carrier; no dysentery.	+	+	—	Vomited.
14654	9.9	Dysentery	+++	+++	—	Normal.
14656	8.3	Cholera in 1902	—	—	—	Do.
14659	8.6	Dysentery in 1915	+	+	—	Vomited.
14660	10.0	Dysentery in 1911	++	+	—	Do.
14670	8.5	Dysentery in 1921	—	+	—	Normal.
14674	9.1	Typhoid in 1921	+	+++	—	Do.
14676	8.9	Dysentery; cholera	++	++++	—	Do.
14678	11.9	Typhoid	—	++++	—	Do.
14679	8.7	Dysentery in 1920	+	+++	—	Do.
14680	8.4	Cholera in 1908	+	+	—	Do.
14685	9.4	Dysentery	+++	+++	—	Do.
14686	7.5	Dysentery in childhood	—	+	—	Do.
14702	8.1	*Entamœba histolytica* carrier; no dysentery.	+++	+++	—	Do.
14704	7.6	Cholera in childhood	+	+	—	Do.
57342	7.6	*Entamœba histolytica* carrier; no dysentery.	—	—	—	Do.
14711	8.3	*Entamœba histolytica* carrier; no dysentery.	—	—	—	Headache; abdominal pain.
14713	10.0	Cholera and dysentery	—	—	—	Normal.
14723	9.4	*Entamœba histolytica* carrier; no dysentery.	+	+	—	Do.
14727	10.8	Dysentery in 1921	++	++	—	Do.
14728	9.2	*Entamœba histolytica* carrier; no dysentery.	—	+ + +	—	Do.
14730	9.2	*Entamœba histolytica* carrier; no dysentery.	—	—	—	Severe abdominal pain.
19366	11.7	Cholera	—	+ + +	([a])	Normal.
19369	9.8	Cholera; dysentery	—	++	—	Do.
58762	10.0	Dysentery	([b])	([b])	([b])	([b])

[a] Clot. [b] No record.

carbon tetrachloride and got along very well for two days, showing no reaction save a rather large amount of mucus in his stool. Two days after treatment his stool was found to contain free blood and he passed a clot similar to the one passed by the preceding subject. He did not complain of pain or discomfort of any kind and showed no other ill effects. He gave a history of cholera some years previously. He drank tuba in moderation.

These two cases, of course, raise the question of the possible ill effects of carbon tetrachloride on an intestine already weakened by some infectious process. It, therefore, becomes a matter of interest to inquire specifically into the performance of the men in this series, twenty-eight in number, from whom we elicited a history of infectious intestinal affections in the past. The observations on these subjects we have tabulated in Table 5, to admit of ready inspection.

It should be noted that in Table 5 we have not attempted to classify the dysenteries, although it is highly probable that most of them were bacillary in origin. Moreover, it is of passing interest to note that of the seven carriers of *Entamœba histolytica* not one gave a history of dysentery.

The intestinal conditions cited in Table 5 are summarized in Table 6.

TABLE 6.—*Summary of intestinal conditions set forth in Table 5.*

Condition.	Cases.
Cholera	4
Dysentery	11
Dysentery and cholera	3
Diarrhœa	1
Entamœba histolytica carrier (no dysentery)	7
Entamœba histolytica carrier; cholera (no dysentery)	1
Typhoid fever	2

On reviewing the data in Table 5, it will be seen that only two subjects showed any marked general reaction to the drug. Both these men were carriers of *Entamœba histolytica* who gave no history of dysentery. It will be further noted, on comparing the data contained in Tables 5 and 10, that of the men with histories of former intestinal affections, numbering 28 per cent of the total number of men studied, only ten passed excessive quantities (++ to ++++) of mucus in their stools. That number represents 22.7 per cent of the men who passed excessive quantities of mucus after treatment.

In interpreting this, it must be realized that estimations of the relative amounts of mucus in the different stools were not

made on any precise basis. The quantities noted simply are an expression of the judgment of the man who inspected the stools; but they are comparatively accurate.

In conclusion, we feel justified in stating that our observations yield us no information that we consider justifies us in stating that amœbic infection of the bowel wall, or previous dysentery, diarrhœa, cholera, or typhoid fever renders the gut more responsive to whatever irritating properties carbon tetrachloride has than is the uninvolved or undamaged intestine.

The question as to what caused the production of the blood clots in the two cases cited still remains unanswered.

In concluding this section of the paper it should be stated that for many years it has been the rule at Bilibid Prison to administer hookworm treatment to all prisoners when they are admitted and during their period of quarantine before they are finally brigaded. Up to the time this work was started the treatment employed was the administration of thymol. The procedure was looked upon with marked disfavor by the prisoners. So unpopular was it that one of the attendants at the quarantine shed assured us that it was his belief that thymol had kept more men of criminal tendency out of Bilibid than conscience or fear of the law.

After the first squad was treated with carbon tetrachloride we easily could have enlisted the entire population of the quarantine shed for experimental purposes, and we met many requests for treatment from attendants and "trusties" before we finished the work. On one or two occasions it happened that another squad was treated with thymol at about the time one of our groups was undergoing treatment with carbon tetrachloride. The men in our group were quite at ease the following morning, while the other men in the adjoining house were still sustaining the pangs of thymol. Our men gently rallied their less-fortunate fellows much to the amusement of themselves and the onlookers.

OBSERVATIONS ON SUBJECTS SHOWING PHYSICAL DEFECTS

The men in this group may be said to have been fairly representative of the population of the Islands as regards their physical condition. That is to say, they did not present any radical departure as to health and general physical condition from what may be found in any group of Filipinos selected at random. However, the thirty men comprising the group showed some definite pathology when examined before treat-

ment. Eleven exhibited pulmonary disturbances, mainly of a tuberculous nature. There were also some who showed enlargement of the liver or spleen or both, probably of malarial origin. There were some disturbances of the urinary system, some valvular heart lesions, hernias, and the like. Only one or two were frankly sick.

Briefly, it may be stated that none of these men showed any reaction to the drug that differed in any essential form or degree from that shown by men in whom no pathology was detected. Of men showing enlargement of the liver only one was jaundiced, and he suffered no untoward effects from the drug. We were able to detect no influence of the drug on men suffering from valvular disease of the heart or any of the other cardiac irregularities detected by us. All of these cases were studied with particular care. As a matter of fact, twenty-two of these men gave no evidence of any general reaction to the drug.

During treatment of these men, there was a fall in pulse rate in all except two cases, the range being from 6 to 66 beats a minute. The 66-beat fall was due, in all probability, to excitement in the original examination, there being a fall from 130 beats on that occasion to 64 at the time of treatment. There was another, a nonpathologic case, with a pulse rate of 162 at physical examination and 98 on treatment. Neither of these men gave any evidence of cardiac trouble.

Nothing significant was shown by the blood or pulse pressures in these cases. The observations on these men are recorded in Table 7.

TABLE 7.—*Observations on subjects showing physical defects.*

Prisoner No.—	Physical defect.	Dose.	Pulse variation.	Stool.	Urine after treatment.	General reaction.
13112	Active tuberculosis.	8.7	—26	Normal	Granular casts	Vomited.
14641	Liver enlarged; jaundice.	8 9	—28	do	Hyaline casts	Normal.
14643	Valvular lesion heart.	8.3	—10	do	do	Do.
14662	Liver palpable	8.0	—24	do	[a] do	Do.
14663	do	8.9	—32	Mucus, bile	do	Do.
14667	Liver, spleen palpable.	9.0	—14	Mucus	do	Do.
14670	Hydrocœle; hernia.	8.5	—16	do	do	Do.
14672	Old healed tuberculosis.	8.5	—14	Mucus, blood, pus.	do	Nausea and hæmoptysis.

[a] Urine contained casts before treatment.

TABLE 7.—*Observations on subjects showing physical defects*—Continued.

Prisoner No.—	Physical defect.	Dose.	Pulse variation.	Stool.	Urine after treatment.	General reaction.
14675	Pleurisy and adhesions, right lobe.	12.5	—16	Mucus, bile	Hyaline casts	Normal.
14676	Old tuberculosis	8.9	— 6	do	do	Do.
14679	Splenomegaly	8.7	—10	do	Normal	Do.
14689	Liver palpable	7.6	—20	Mucus	Hyaline casts	Do.
14692	do	6.2	—22	Mucus, bile	Trace of albumen, hyaline casts.	Do.
14702	Hernia	8.1	+ 4	do	Hyaline casts	Do.
14707	Active tuberculosis.	9.5	—14	Mucus	[a] Hyaline and granular casts.	Severe headache; vertigo; abdominal pain.
14711	Spleen and liver palpable.	8.3	—19	Normal	Hyaline casts	Headache; abdominal pain.
14712	Acute nephritis	9.3	(?)	Mucus, bile	[b] Albumin pus casts	Severe headache; abdominal pain; vertigo.
14715	Old healed tuberculosis.	10.8	—12	Mucus	Granular casts	Normal.
14721	Splenomegaly	11.1	— 6	Mucus, bile	Normal	Vomited.
14722	do	10.8	— 6	do	do	Fever 100.5°, vertigo; abdominal pain.
14723	do	9.4	—66	do	[a] Hyaline casts	Normal.
14725	do	10.8	—18	do	Hyaline and granular casts.	Do.
14729	Tuberculosis left lung.	9.2	—12	do	do	Do.
14730	Spleen and liver palpable.	9.2	—10	Normal	Trace of albumin; hyaline and granular casts.	Severe abdominal pain.
19188	Old tuberculosis; bronchitis.	7.3	— 8	Mucus, bile	Hyaline casts	Normal.
19369	Valvular heart lesion.	9.8	—20	Mucus	[a] do	Do.
19370	Old healed tuberculosis.	8.7	—46	do	Trace of albumin; hyaline and granular casts.	Do.
57128	Asthma	8.9	+18	Mucus, bile	Hyaline and granular casts.	Do.
57340	Old healed tuberculosis; hernia.	7.1	—34	Mucus	Hyaline casts	Do.
57343	Old tuberculosis	7.1	—10	Mucus, bile	Not examined	Do.

[a] Urine contained casts before treatment. [b] Urine contained albumin before treatment.

ALCOHOLISM AND THE ADMINISTRATION OF CARBON TETRACHLORIDE

A question always arises as to the wisdom of administering carbon tetrachloride to a person of known alcoholic habits who presents himself for the treatment of hookworm infection. Admittedly the association of the drug with alcohol is fraught

with a certain amount of risk, especially in the case of the constant and heavy drinker. Our study of these cases, however, has led us to the belief that the drug may be administered with perfect safety to persons who indulge moderately in alcoholic drinks, provided they are willing to forego them for three or four days prior to taking the drug. We are of the opinion, however, that carbon tetrachloride should be given with the utmost caution to those who drink habitually to the point of intoxication, and it also should be withheld from those who are not willing to abstain from alcohol for a few days before and after treatment.

Lambert(6) says that alcoholism is a contraindication and that liquor should not be taken for "several hours" before and after treatment. We prefer to err on the side of prudence, however, and withhold alcohol from our patients for three or four days prior to treatment.

Notwithstanding we have treated many persons who have admitted the use of alcohol in a moderate degree, and several who were not so abstemious, we have been able, by withdrawing alcohol for the time stated, to avoid the untoward effects that show themselves in alcoholics. However, we have noted the effects of disregard of this precaution in men treated by practicing physicians.

One case was afforded by an American business man whose daily regimen included several glasses of "Scotch and soda," but who could not be classed as a drunkard. Following the finding of hookworm ova in his stools, he was referred to his physician, who had treated several patients with carbon tetrachloride and was quite familiar with the contraindications to its use. Unfortunately he failed to caution his patient.

So the man attended a business luncheon, indulging in two cocktails and a heavy course meal. Later in the afternoon he partook of four Scotch and sodas and shortly afterwards drank 8.5 cubic centimeters of carbon tetrachloride. He was violently nauseated at intervals during the night and his bowels moved freely. The following day he became markedly jaundiced and very weak, and the jaundice persisted for two days, after which he recovered and showed no further ill effects except a marked distaste for carbon tetrachloride.

The second case was presented by a Spaniard engaged in business in the provinces who contracted a hookworm infestation that gave rise to a marked anæmia. He had an eosinophilia of 11 per cent. He was treated by his family physician and

gave the following performance, the notes on which were furnished by his physician:

August 4. Calomel, 3 grains at bedtime.

August 5. Epsom salts in morning. Liquid diet.

August 6. No breakfast. Nine cubic centimeters of carbon tetrachloride given at 9 a. m.

Two hours after taking the medicine his bowels began to move, and the purging continued all day. His chief complaint was a burning sensation at the anus. Many worms were recovered, but no count was made.

August 7. The patient complained of pain in the stomach. He vomited many times during the day and night, the vomitus containing mucus and bile.

August 8. The patient vomited frequently during the day. In the evening he was given a hypodermic of pantopon. He slept well and had no recurrence of the pain or the vomiting.

August 9. The patient became markedly jaundiced. His urine was very dark, containing bile, but no albumin, sugar, or casts.

August 12. Discharged from the hospital. The jaundice was beginning to fade. His appetite was good.

The patient was instructed to report again in two weeks for another stool examination, but he failed to do so. However, his friends stated that he was gaining in weight and had a ravenous appetite. He went back to his work in the provinces.

Particulars regarding the extent of the alcoholic indulgences of this man were not forthcoming, but there seems little reason to doubt, from such information as we could secure, that his troubles were consequent upon a too-close association between alcohol and carbon tetrachloride.

These are two fairly extreme cases. Others we have seen were milder, but all recovered and showed no outward effects after convalescence. Obviously, the drug had spent considerable force on the liver in every case and there is, of course, no means of telling at the present time if the damage wrought was of a permanent nature.

Nothing of this kind occurred among our prisoners, however. Statistically, so far as abnormal reactions following treatment are concerned, our "alcoholic group" made a distinctly better showing than did those who denied the use of liquor. Out of the entire group, forty-eight men asserted that they used alcohol in moderation, while two admitted that they used it in excess. Fifty-five of the men denied the use of alcohol in any form, while five failed to make a statement either way. None of these men were whiskey drinkers. A few drank beer, but most of them indulged in tuba, which is quite freely drunk in some of the rural districts. None of the men had tasted liquor in any form for at least a week prior to treatment.

Preliminary to a discussion of the observations made on these men, we present Table 8, which summarizes the reactions in the alcoholic and nonalcoholic groups.

TABLE 8.—*Résumé of reactions in subjects admitting and denying the use of alcohol.*

Symptom.	Use of alcohol— Admitted.		Use of alcohol— Denied.	
	Number.	*P. ct.*	*Number.*	*P. ct.*
Vomiting	3	7.5	10	18.0
Blood and pus in stool [a]	2	5.0		
Blood clot in stool	1	2.5		
Abdominal pain	2	5.0	3	5.4
Abdominal pain and vomiting	1	2.5		
Bile and mucus in stool	25	62.0	28	50.0
Bile in stool	1	2.5	4	7.2
Mucus in stool	10	25.0	7	12.7
No abnormal reaction	32	80.0	35	63.6

[a] Study of the cellular exudate in the stools of these men indicates that they were suffering from mild bacillary dysentery.

With the foregoing table as an introduction, we shall now consider these various reactions in terms of the proportionate amounts of the drug administered to the different men. To do this we shall assemble the subjects into four groups on the above basis. This classification, besides being in conformity with the plan followed by us in regulating the dosage for the different subjects, admits of clearer analysis than any other method. The four groups consist of—

1. Men receiving 1 cubic centimeter of carbon tetrachloride to each 7 kilograms of body weight.
2. Men receiving 1 cubic centimeter to each 6.5 kilograms of body weight.
3. Men receiving 1 cubic centimeter to each 6 kilograms of body weight.
4. Men receiving 1 cubic centimeter to each 5.5 kilograms of body weight.

Table 9 shows the average dose received by the men in each group as well as the extremes.

TABLE 9.—*Average actual dose and range of dose of carbon tetrachloride as calculated on basis of kilograms of body weight.*

One cubic centimeter to each—	Subjects.	Average dose.	Range of dosage.	Average weight.
		cc.	*cc.*	*Kg.*
7 kilograms body weight	25	7.7	6.2– 9.4	54.5
6.5 kilograms body weight	9	7.8	6.9– 9.4	51.3
6 kilograms body weight	29	9.1	8.0–12.5	55.0
5.5 kilograms body weight	33 (37)	10.0	8.3–12.5	55.0

The reactions of the individual men in the four groups are set forth in Table 10.

TABLE 10.—*General reaction of alcoholic and nonalcoholic subjects following treatment with carbon tetrachloride.*

GROUP 1. SUBJECTS TREATED ON BASIS OF 1 CUBIC CENTIMETER OF CARBON TETRACHLORIDE TO EACH 7 KILOGRAMS OF BODY WEIGHT.

Prisoner No.—	Alcohol.	Stool findings. Mucus.	Stool findings. Bile.	Actual dose.	General reaction.
				cc.	
14680	Tuba, moderate	+	+	8.4	Normal.
14681	Denied	+	+	9.0	Do.
14682	do	----	----	6.6	Do.
14683	do	+	+	8.3	Weak and unable to walk two days after.
14684	do	----	----	6.6	Normal.
14685	Beer, moderate	+++	+++	9.4	Gas; otherwise normal.
14686	Tuba, moderate	+	----	7.5	Normal.
14687	do	+++	+++	9.4	Do.
14689	Denied	+	----	7.6	Do.
14690	do	+	+	8.7	Do.
14691	do	+	+++	9.0	Do.
14692	Tuba, moderate	+	+	6.2	Do.
14693	Denied	+++	+	7.1	Do.
14694	do	+	+++	7.5	Do.
14695	do	+	+++	6.2	Do.
[a] 14702	Tuba, moderate	+++	+++	8.1	Do.
14703	do	+	----	8.2	Do.
14704	do	+	+	7.6	Do.
[a] 14705	Denied	++	++	7.8	Do.
57340	Tuba, moderate	+	----	7.1	Do.
57341	Denied	+++	+++	8.3	Do.
[a] 57342	Tuba, moderate	----	----	7.6	Do.
57343	do	+++	+++	7.1	Do.
[a] 57345	Denied	----	+++	6.2	Do.
57346	Tuba, moderate	+++	+++	7.8	In hospital from other causes; pain in stomach after treatment.

[a] Hookworm ova found after treatment.

GROUP 2. SUBJECTS TREATED ON BASIS OF 1 CUBIC CENTIMETER OF CARBON TETRACHLORIDE TO EACH 6.5 KILOGRAMS OF BODY WEIGHT.

14579	Denied	----	----	8.1	Normal.
14646	do	----	----	7.5	Vomited after eating.
19188	do	++	++	7.3	Normal.
19189	do	+	+	6.9	Do.
56471	Beer, moderate	+	+	7.7	Vomited after water.
57128	Denied	+++	+++	8.9	Normal.
57129	do	+++	+++	9.4	Do.
57139	do	----	+++	7.7	Do.
57140	do	----	----	7.1	Do.

GROUP 3. SUBJECTS TREATED ON BASIS OF 1 CUBIC CENTIMETER OF CARBON TETRACHLORIDE TO EACH 6 KILOGRAMS OF BODY WEIGHT.

11389	Denied			8.8	Normal.
14643	do			8.3	Do.
14654	do	+++	+++	9.9	Do.
14656	do			8.3	Do.
14657	do	++	++	10.0	Do.
14658	do		+	10.4	Do.
14659	do	+	+	8.6	Vomited.
14660	do	+	++	10.0	Do.
14661	Moderate		+	8.9	Gas; no other trouble.
14662	Denied			8.0	Normal.
14663	Moderate	++	+	8.9	Gas; no other trouble.
14664	Denied	+++	+++	8.0	Normal.
14666	Tuba, moderate	++	++	8.6	Do.
14667	Denied	++++		9.0	Do.
14668	Excess	+	+	8.3	Frequent and painful, bloody, mucoid stools; probably bacillary dysentery.
14669	Denied	+	+	9.3	Normal.
14670	Tuba, moderate	+		8.5	Do.
14671	do	+++	+++	9.8	Do.
14672	do	+		8.5	Nausea five days; blood and pus in stool; probably bacillary dysentery; hæmoptysis; tuberculosis.
14673	Denied	+	+	9.1	Normal.
14674	Tuba, moderate	+++	+	9.1	Do.
14675	do	+++	+	12.5	Do.
14676	Tuba excess	++++	++	8.9	Gas; no other trouble.
14677	Denied	+++	+	8.3	Normal.
14678	Tuba, moderate	++++	++	11.9	Do.
14679	Denied	+++	+	8.7	Do.
19174	do			8.8	Slight vomiting.
57112	do			8.0	Normal.
57600	do			8.1	Slight vomiting after food.

GROUP 4. SUBJECTS TREATED ON BASIS OF 1 CUBIC CENTIMETER OF CARBON TETRACHLORIDE TO EACH 5.5 KILOGRAMS OF BODY WEIGHT.

13112	Denied			8.7	Vomited.
14641	do			8.9	Normal.
[a] 14642	do			10.8	Vomited.
14707	do	+++		9.5	Severe headache and vertigo; abdominal pain.
14708	Moderate	+	+	11.3	Normal.
14709	Denied	+	+++	10.3	Do.
14710	do	++	+++	11.2	Pain in stomach, twelve hours.
14711	Tuba, moderate			8.3	Headache and abdominal pain.
14712	Denied	+	+	9.3	Severe headache and vertigo; abdominal pain.

GROUP 4. SUBJECTS TREATED ON BASIS OF 1 CUBIC CENTIMETER OF CARBON TETRACHLORIDE TO EACH 5.5 KILOGRAMS OF BODY WEIGHT—Continued.

14713	Denied	+	+	10.0	Normal.
14714	do.	+++		9.0	Vomited.
14715	do.	++		10.8	Normal.
14717	do.		+++	10.0	Do.
[a] 14718	do.	+++	+++	12.0	Do.
14719	do.	+	+++	9.4	Vomited.
14721	Tuba, moderate	+	+	11.1	Do.
14722	do.	+	+	10.8	Fever 100.6°; vertigo; abdominal pain, one hour after treatment.
[a] 14723	do.	+	+	9.4	Normal.
14724	do.	+		9.4	Do.
14725	do.	+++	+++	10.8	Do.
[a] 14726	Gin and tuba moderate	+		8.9	Do.
14727	do.	++	++	10.8	Do.
14728	Tuba, moderate	+++		9.2	Do.
14729	do.	+	+	9.2	Do.
[a] 14730	do.			9.2	Severe abdominal pain, one hour after treatment.
14731	do.	+	+	8.7	Normal.
14733	do.	+		11.6	Do.
14966	No record			8.7	No record.
14969	do.	+++		12.5	Do.
15001	do.			10.4	Do.
19180	Denied			10.8	Vomited.
[b] 19366	Moderate	+++		11.7	Normal.
19367	No record	+	+	9.3	Do.
19369	Denied	++		9.8	Do.
19370	do.	+		8.7	Do.
57127	Tuba, moderate			11.4	Do.
58762	No record			10.0	No record.

[a] Hookworm ova found after treatment.
[b] This patient passed a blood clot from the intestine after treatment.

Unfortunately, a wide numerical discrepancy exists between the subjects composing group 2 (the 6.5-kilogram group) and the other three groups; nevertheless, the comparative figures are interesting. This interest is aside from the question of whether the men were or were not alcoholic; for by this time it will be seen that, if anything, the "alcoholics" appear to have the best of the bargain so far as concerns immunity to the effects of the drug. Aside from the second group, already mentioned, it will be seen that the other three groups afford a good basis of discussion of the effects of a drug administered on the kilogram-of-body-weight basis, because the average weights of the men in each group are practically identical. The second group, containing only nine men, does not afford a good basis for comparison.

To begin: The first group of twenty-five subjects, having an average weight of 54.5 kilograms, received an average dose of carbon tetrachloride amounting to 7.7 cubic centimeters, calculated on a basis of 1 cubic centimeter of the drug to each 7 kilograms of body weight. None of the men in this group vomited. In fact, only two men showed reactions barely over the threshold of those we have arbitrarily designated as "normal." On a liberal interpretation, therefore, we state that 4 per cent of the men in this group showed slightly unpleasant symptoms.

The second group of men, nine in number, of an average weight of 51.3 kilograms, received an average dose of 7.8 kilograms of carbon tetrachloride, calculated on a basis of 1 cubic centimeter of the drug to each 6.5 kilograms of body weight. By referring to Table 9, it will be seen that the average dose and the range of dose show very little variation over those of the preceding group, which taken with the numerical strength of the group makes clear the fallacy involved in the 22 per cent abnormal reactions we are forced to charge against the two men who vomited after treatment.

A more satisfactory basis of calculation is afforded by the third group. This consisted of twenty-nine men, whose average weight was 55 kilograms, and who received an average dose of 9.1 cubic centimeters of carbon tetrachloride, calculated on a basis of 1 cubic centimeter of the drug to each 6 kilograms of body weight. Six of these men were sick after treatment, but we feel that only four of the reactions should be charged against the drug. Two of the men passed stools that contained blood, pus, and mucus thirty-six hours after treatment, at which time they had wholly recovered from the very slight reaction they exhibited to the drug. On careful study of stained preparations made from these stools, we are convinced that these two men suffered a slight exacerbation of bacillary dysentery which bore no direct relation, at least, to the treatment. The other four men had vomiting of varying degrees of severity probably largely the result of eating too heavy a meal four or five hours after the drug was administered, but exhibited no other ill effects. Therefore, we record 14 per cent of symptoms above our normal in this group.

The fourth and final group consisted of thirty-seven men; but, as the records are imperfect in certain particulars in four instances, we have figured on a basis of thirty-three men. The average weight of the men in this group was 55 kilograms,

and they received an average dose of 10 cubic centimeters of carbon tetrachloride, calculated on a basis of 1 cubic centimeter of the drug to each 5.5 kilograms of body weight. Eleven of these men, or 33.3 per cent, showed abnormal reactions. Many of these reactions were more pronounced than those shown by the men in the other groups. One man complained of severe pain in the stomach; five vomited; and five complained of severe headache, vertigo, and abdominal pain. Another man passed a blood clot in his stool two days after treatment, but he showed no symptoms of ill effects at any other time.

To summarize, it will be seen that 18.7 per cent of the men in the series from whom we secured complete data showed clinical reactions to the drug that may be regarded as approaching the undesirable. In no case, however, did symptoms of an alarming nature supervene, and the disturbances in all cases were purely transitory. It should be especially noted that 61.1 per cent of those showing abnormal reactions were men in the fourth group, who received treatment on a basis of 1 cubic centimeter of carbon tetrachloride to each 5.5 kilograms of body weight. We are not disposed to argue the point with those who may assert that such a dose is in excess of the amount required to dislodge the worms. We think it highly probable that such a dose is not necessary in the majority of instances. The point we wish to emphasize, however, is that this dose is perfectly safe *provided the drug is of established purity and no physical contraindications exist in the patient.*

In support of the above statement, we feel that it is opportune to state at this time that within the past few months there have been treated on Cebu Island, under the supervision of Dr. Cristobal Manalang, of the Philippine Health Service, more than 25,000 hookworm-infested Filipinos of both sexes and all ages. Working under our direction, Doctor Manalang has administered the drug on the basis of 1 cubic centimeter to each 5.5 kilograms of body weight. There have been no deaths, and in no case have toxic symptoms of any moment arisen. Every liter of the drug used in Cebu, before being shipped there, was subjected to careful test and refinings at the Bureau of Science, under supervision of Mr. Wells. Finally, it must be stated that a large proportion of the residents of Cebu drink freely of tuba, and it is extremely likely that a large number of these drank tuba within relatively short periods before undergoing treatment.

Regarding the relative efficacy of the drug in the proportions administered in these four groups, it is to be noted that four

men in the first group showed hookworm ova in their fæces several weeks after treatment, and five men also were positive in the fourth group on reëxamination. The men in the middle two groups all were microscopically negative when their fæces were reëxamined.

Two facts, therefore, are made plain by the foregoing, namely:

1. Carbon tetrachloride may be safely given in a proportion of 1 cubic centimeter to each 5.5 kilograms of body weight, up to an actual dose of 12.5 cubic centimeters. It will be seen by Table 10 that symptoms of an abnormal nature bear no real relation to the actual amount of the drug taken, for they are as likely to arise following the administration of the smaller amounts as of the larger volumes.

2. Moderate alcoholism is no contraindication to the use of carbon tetrachloride, provided liquor is withheld from the patient for several days before and after treatment, and provided there is no involvement of the liver or alimentary tract.

THE URINE

In the study of these men we obtained no evidence that would indicate that carbon tetrachloride, administered in doses ranging from 6.2 to 12.5 cubic centimeters, exerts a deleterious effect on the kidneys that is more than transitory. In only two subjects was albumin detected after treatment where it had not already been found before treatment. In three instances albumin was found before treatment, but not afterwards, and in four other cases albumin was present both before and after treatment.

In one instance we administered 9.3 cubic centimeters of the drug to a man (prisoner 14712) who showed definite evidence of renal disturbance. During treatment this man complained of severe headache and abdominal pain, but the phenomena differed in no way from those shown by several men exhibiting the same symptoms, after treatment, but whose kidneys appeared to be clear. Before treatment, this man's urine was strongly positive for albumin; it contained also leucocytes and erythrocytes. Forty-eight hours after treatment, the albumin reaction was even stronger, and many leucocytes and hyaline and granular casts were present. Physically, however, the man seemed no worse during the period he was under observation.

The occurrence of casts (hyaline and granular) was frequent, however. Forty-two of the men had casts in their urine after treatment, though none had been detected before. Casts were present both before and after treatment in twenty-five subjects,

and before treatment, only, in seven others. In passing, it may be remarked that we have observed that hyaline and granular casts are of frequent occurrence, without an associated albuminuria, in a large proportion of Filipinos who are in apparently normal health, so that undue significance should not be placed on these findings.

The urine of many of the men showed a tendency to assume a darker hue immediately after treatment. However, in only one instance was a test for bile positive. This was the case of prisoner 14704, who received 7.6 cubic centimeters of carbon tetrachloride, on the basis of 1 cubic centimeter to each 7 kilograms of body weight. His urine was negative for albumin and casts, both before and after treatment. It was very dark in color after treatment and of a specific gravity of 1.026. Leucocytes in small numbers were present, both before and after treatment.

This man showed no physical reaction to the drug, and the watery stools passed by him contained only small quantities of bile and mucus. His liver was not palpable. He did not become jaundiced.

We have not undertaken to analyze the other data obtained by urinalysis, because standards bearing on the routine clinical examination of Filipino urine are not available. We would say, parenthetically, that we encountered nothing that we are inclined to regard as especially significant to this study. The pathological findings in the urines made by us are recorded in Table 11.

THE BLOOD

Notwithstanding the study of the blood of these subjects was carried out with all the care and thoroughness possible under the methods employed, the data collected are almost too bizarre to be treated in detail. However, we feel justified in drawing certain conclusions on the basis of our blood findings.

A large proportion of subjects showed a distinct polycythæmia and high hæmoglobin percentage. Such conditions in a group of men known to harbor hookworm naturally awakened our interest. However, it is, in a large measure, explained by the low worm counts, more than 90 per cent of which were below 100.

The total erythrocyte counts of seventy-four of the subjects showed 5,000,000 or more erythrocytes per cubic millimeter. Of these, eighteen men showed a count of above 6,000,000, and six men above 7,000,000 erythrocytes. Hæmoglobin estima-

TABLE 11.—*Urine, before and twenty-four hours after treatment; cases showing albumin, casts, or both.*

Prisoner No.—	Dose.	Before treatment.		After treatment.	
		Albumin.	Casts.	Albumin.	Casts.
	cc.				
13112	8.7				Few granular.
14641	8.9				Occasional hyaline.
14642	10.8				Do.
14643	8.3				Do.
14646	7.5				Do.
19174	8.8				Do.
57600	8.1				Do.
19188	7.3				Hyaline.
56471	7.7				Do.
57112	8.0	+		Faint trace	Granular.
57127	11.4		Granular		Occasional hyaline.
57128	8.9				Long hyaline; few granular.
57129	9.4			Trace	Occasional hyaline.
14654	9.9		Occasional hyaline		None.
14656	8.3				Few hyaline.
14657	10.0		Hyaline		Hyaline.
14658	7.4		do		Do.
14659	8.6				Do.
14661	9.9		Hyaline		Do.
14662	8.0		do		Do.
14663	8.9				Hyaline and granular.
14664	8.9			+	Few short hyaline
14666	8.6	+		+	
14667	9.0				Few hyaline.
14669	9.3				Hyaline.
14670	8.5				Many short hyaline.
14671	9.8		Few hyaline		None.
14672	8.5		do		Few hyaline.
14673	9.1		Occasional hyaline		None.
14674	9.1		Hyaline		Hyaline.
14675	12.5		do		Do.
14676	8.9		do		Do.
14677	8.3				Occasional hyaline and granular.
14678	11.9				Occasional hyaline.
14680	8.4		Occasional hyaline		Numerous hyaline.
14681	9.0				Occasional hyaline.
14683	8.3		Occasional hyaline		Do.
14684	6.6				Do.
14685	9.4		Occasional hyaline		Negative.
14687	9.4				Few hyaline.
14689	7.6				Occasional hyaline
14690	8.7		Hyaline and granular		Hyaline.
14691	9.0				Occasional hyaline.
14692	6.2			Slight trace	Do.
14693	7.1				Do.

TABLE 11.—*Urine, before and twenty-four hours after treatment; cases showing albumin, casts, or both*—Continued.

Prisoner No.—	Dose.	Before treatment.		After treatment.	
		Albumin.	Casts.	Albumin.	Casts.
	cc.				
14694	7.5	+		(?)	Hyaline.
14695	6.2		Hyaline		Do.
[a] 14702	8.1				Occasional hyaline.
14705	7.8				Do.
57340	7.1	Trace		Negative	Do.
57342	7.6		Hyaline		Hyaline.
57345	6.2		Few hyaline		Few hyaline.
57346	7.8			Trace	
14707	9.5		Occasional hyaline	Faint trace	Few hyaline and granular.
14708	11.3	+	Few hyaline and granular.	Trace	Negative.
14709	10.3		Occasional small hyaline.		None.
14710	11.2		Granular	Faint trace	Occasional hyaline.
14711	8.3				Do.
[b] 14712	9.3	+		+++	Many short hyaline and granular.
14713	10.0				Occasional hyaline.
14714	9.0		Many		Few large hyaline.
14715	10.8				Few granular.
14718	12.0		Few		None.
14723	9.4		Occasional hyaline		Occasional hyaline.
14724	9.4		Number of hyaline		Few hyaline.
14725	10.8				Large number of hyaline and granular.
14726	8.9	+	Many granular; few hyaline.	Trace	Few hyaline and granular.
14727	10.8	Slight trace	Few	Negative	Great number of hyaline and granular.
14728	9.2				Occasional hyaline.
14729	9.2	Trace		Negative	Hyaline and granular.
14730	9.2			Trace	Few hyaline and granular.
14731	8.7		Hyaline		Great number of hyaline and granular.
14733	11.6	+		Negative	Few hyaline.
19367	9.3		Occasional hyaline		Occasional hyaline.
19369	9.8		Few granular		Few hyaline.
19370	8.7			Slight trace	Few hyaline and granular.
58762	10.0	Trace		Not done	Not done.

[a] Urine contained bile after treatment.

[b] Urine also contained mucus, leucocytes, and erythrocytes before treatment, and leucocytes after treatment in addition to the other elements noted.

tions of 90 per cent or more were made on fifty-nine men. In only two cases were low erythrocyte counts and hæmoglobin estimations associated with worm counts of 100 or more, as is shown by Table 12. Particular attention is drawn to case 14658 in that table, in which the highest worm count is seen to be associated with the highest erythrocyte count and one of the highest hæmoglobin estimations. On screening the stools of this man 1 *Ancylostoma* and 354 *Necator* were recovered.

TABLE 12.—*Total erythrocyte counts and hæmoglobin estimations in nine subjects from whom 100 or more hookworms were recovered after treatment.*

Prisoner No.—	Worm count.	Erythrocytes.	Hæmoglobin.
			Per cent.
14726	100	4,050,000	45
14702	121	5,450,000	85
14705	149	5,500,000	88
57342	148	4,850,000	58
57345	303	3,900,000	35
14642	118	5,360,000	88
14659	244	4,720,000	93
14680	154	5,500,000	85
14658	355	6,130,000	88

It is difficult to say whether or not these high erythrocyte counts are due to increased oxidation in the Tropics. On the other hand, it should be noted that these counts were made during the month of May, which is the height of the hot, dry season in Manila, in consequence of which there may be an association between the polycythæmias and a decreased fluid content of the blood. These are points that can only be determined by extensive investigation. It is suggestive of a lack of reaction, or a failure on the part of the subject to experience serious effects from the presence of intestinal parasites. Only four of the men had erythrocyte counts that fell below 4,000,000, and only a like number exhibited a hæmoglobin percentage that fell below 70.

These figures are startlingly at variance with those we obtained on study of the blood of eleven cases of hookworm anæmia in Cebu.(8) In that series the total erythrocyte counts ranged from 1,380,000 in a heavily infected case, up to 3,330,000 in a case that already had been treated with chenopodium but still retained a light infection. In the Cebu series the hæmoglobin

percentages ranged from a point below the 10 per cent mark on the Tallquist scale up to 70. The total erythrocyte counts and hæmoglobin estimations made before treatment are summarized in Tables 13 and 14.

TABLE 13.—*Distribution of total erythrocyte counts before treatment.*

Erythrocytes per cubic millimeter.	Subjects.
3,000,000 and over	4
4,000,000 and over	22
5,000,000 and over	50
6,000,000 and over	18
7,000,000 and over	6

TABLE 14.—*Hæmoglobin estimations before treatment.*

Hæmoglobin. Per cent.	Subjects.
90–100	59
80–89	34
70–79	3
60–69	1
50–59	1
40–49	1
30–39	1

Relatively little work has been done on the red elements of the blood of Filipinos, but our findings are in substantial agreement with those of other observers who have dealt with similar subjects. On differential leucocyte counts we recorded an average of 51 per cent polymorphonuclear neutrophiles. Guerrero and Sevilla(3) report an average of 51.6 in their series, and Chamberlain(1) a range of from 47 to 52 per cent in his various series of Filipinos.

After treatment, we noted a tendency toward a rise in the proportion of polymorphonuclear neutrophiles during the first twenty-four hours following the administration of the drug. A varying degree of increase was noted in fifty-eight of the men. This effect, however, was not permanent, for after a period of about two months only thirty-eight of the men showed a continued elevation above the count made before treatment.

Perhaps the most striking feature of the blood picture was the practically universal eosinophilia. This is set forth in Table 15, in which the eosinophile counts are associated with the hookworm counts. It will be seen that the correlation is very loose. It may be mentioned, in passing, that no skin affections existed among these men that would influence the eosinophile count. One man gave a history of asthma. He had 10 per cent

eosinophiles at the first examination which had fallen to 6 per cent three and one-half months later. We recovered seven *Necator* after treating him.

TABLE 15.—*Relation of eosinophilia to number of hookworms recovered after treatment.*

[A = *Ancylostoma duodenale*. N = *Necator americanus*.]

Prisoner No.—	Hookworms recovered.	Eosinophilia.			Interval between counts.		Differential worm counts.
		Before.	After.	Differences.			
		Per cent.	*Per cent.*	*Per cent.*	*Months.*	*Days.*	
14641	69	14.0	2.5	—11.5	3	21	4 A, 65 N.
14642[a]	118	27.0	8.5	—18.5	3	21	32 A, 86 N.
14646	9	18.5	3.5	—15.0	3	15	
19180	8	7.0	2.0	— 5.0	3	21	
19188	12	4.5	4.0	— 0.5	3	17	
57127	23	5.0	5.0	— 0.0	3	21	
57129	0	10.0					
57140	12	9.0					
14654	23	3.5					
14656	2	0.5					
14657	31	7.0					
14658	355	5.0					
14659	244	4.5	5.5	+ 1.0	3	11	
14660	38	5.5	6.5	+ 1.0	3	11	
14661	18	6.5	4.0	— 2.5	3	8	
14662	70	4.5	5.5	+ 1.0	3	8	
14663	10	8.0					
14664	4	6.5	2.5	— 4.0	3	8	
14666	0	10.5	7.0	— 3.5	3	8	
14667	9	6.0					
14668	73	26.5					29 A, 34 N.
14669	6	10.0	7.0	— 3.0	3	6	
14670	24	18.5	4.0	—14.5	3	6	4 A, 20 N.
14671	8	7.5	12.0	+ 4.5	3	7	
14672	7	11.5	10.0	— 1.0	3	7	
14673	9	10.5	7.0	— 3.5	3	7	
14674	44	4.0	22.0	+18.0	3	2	20 A, 24 N.
14675	13	5.5	10.0	+ 4.5	3	2	
14676	19	14.0	8.0	— 6.0	3	2	
14677	56	27.5	9.0	—18.5	3	2	19 A, 37 N.
14678	1	6.5	16.0	+ 9.5	3	2	
14679	2	3.0	2.0	— 1.0	3	2	
14680	154	10.0	13.0	+ 3.0	2	21	8 A, 146 N.
14681	0	10.0	18.0	+ 8.0	2	21	
14682	2	5.5	9.0	+ 3.5	2	21	
14683	3	12.5	6.5	— 6.0	2	21	
14684	0	9.5	6.5	— 3.0	2	21	
14685	11	7.0	10.0	+ 3.0	2	21	
14686	26	10.5	1.0	— 9.5	2	21	14 A, 12 N.
14687	2	11.5	10.0	— 1.5	2	21	

[a] Hookworm ova found after treatment.

Table 15.—*Relation of eosinophilia to number of hookworms recovered after treatment*—Continued.

Prisoner No.—	Hookworms recovered.	Eosinophilia.			Interval between counts.		Differential worm counts.
		Before.	After.	Differences.			
		Per cent.	*Per cent.*	*Per cent.*	*Months.*	*Days.*	
14689	72	16.5	0.0	—16.5	2	18	10 A, 62 N.
14690	16	17.0	11.5	— 5.5	2	18	2 A, 14 N.
14691	17	8.0	4.0	— 4.0	2	18	5 A, 12 N.
14692	16	5.5	3.5	— 2.0	2	19	3 A, 13 N.
14693	9	6.5	7.0	— 0.5	2	19	
14694	0	6.5	1.0	— 5.5	2	19	
14695	2	3.5	2.0	— 1.5	2	19	
14702 [a]	121	5.0	22.0	+17.0	2	19	11 A, 110 N.
14703	22	7.0	5.0	— 2.0	2		
14704	13	6.5					
14705 [a]	149	23.0	18.0	— 5.0	2	16	12 A, 137 N.
57340	0	11.0					
57341	98	14.0	10.0	— 4.0	2	16	36 A, 62 N.
57342 [a]	148	11.0	33.0	+22.0	2	16	6 A, 142 N.
57343	56	13.0					19 A, 37 N.
57345 [a]	302	9.5	31.0	+21.5	2	16	32 A, 270 N.
57346	1	7.5	12.0	+ 4.5	2	16	
14707	78	16.5	9.0	— 7.5	2	8	78 N.
14708	91	19.0	9.0	—10.0	2	8	91 N.
14709	5	12.0	7.5	— 4.5	2	8	5 A.
14710	0	9.0	10.0	+ 3.0	2	8	
14711	4	15.5	6.5	— 9.0	2	8	
14712	26	13.0	16.0	+ 3.0	2	8	26 A.
14713	25	8.5	3.5	— 5.0	2	9	
14714	2	22.0	4.0	—18.0	2	9	
14715	21	16.5	8.0	— 8.5	2	6	
14717	16	7.5	7.5	0.0	2	6	
14718 [a]	43	6.5	7.5	— 1.0	2	6	
14719	9	3.5	7.0	+ 3.5	2	6	
14721	7	25.5	17.0	— 8.5	2	6	7 N.
14722	2	14.0	4.0	—10.0	2	6	2 N.
14723 [a]	9	21.5	0.0	—21.5	2	6	7 A, 2 N.
14724	7	10.5	7.5	— 3.0	2	4	3 A, 4 N.
14725	30	14.0	9.0	— 5.0	2	4	8 A, 22 N.
14726 [a]	100	1.5	12.0	+10.5	2	4	23 A, 77 N.
14727	97	24.0	12.5	—11.5	2	4	27 A, 50 N.
14728	24	14.5	8.5	— 6.0	2	4	5 A, 19 N.
14729	46	24.0	3.0	—21.0	2	4	9 A, 37 N.
14730 [a]	22	16.5	1.5	—15.0	2	4	2 A, 20 N.
14731	37	12.5	3.0	— 9.5	2	4	16 A, 21 N.
14733	10	21.5	2.5	—19.0	2	4	6 A, 4 N.
19366	97	5.5					49 A, 48 N.
19367	15	10.5					14 A, 1 N.
19369	7	1.0					
19370	12	2.0					

[a] Hookworm ova found after treatment.

Assuming 4 per cent as a liberal normal high eosinophile count, only nine cases will be seen to present a normal eosinophilia. A number of very high counts were found, the highest being 33 per cent. Ten of the counts made before treatment were above 20 per cent.

This is in sharp contrast to the blood picture presented by the group of subjects in Cebu who were suffering from advanced hookworm disease, recently studied by us,(8) in which the anæmia was profound and in none of whom did we find an eosinophile count above 7 per cent.

In the majority of the subjects infested with hookworm, there was a distinct lowering of the eosinophiles during the two months following treatment. This was particularly noticeable in many of the cases that showed a high percentage of eosinophiles on the initial count. In subjects who gave low original counts, there are a few instances in which a rise is recorded. In some of these instances, it will be seen that microscopic examination had shown the men to have retained their infections after treatment. Some of these persistent positives may have been men in whom an infection was developing at the time of their admission to the prison, for they came into our hands almost immediately after commitment. It also must be borne in mind that very few of the men were cleared of their entire helminthal infection, *Ascaris* and *Trichuris* persisting in many cases. Nevertheless, twenty-five of the examinations made two months after treatment show a normal eosinophilia (4 per cent or less). The highest percentages were found in those still retaining hookworms.

HOOKWORM DISEASE

None of the subjects studied in this series presented a clinical picture that could be regarded as one of extreme hookworm disease. In fact, practically 90 per cent of the men showed no symptom that could be attributed to hookworm infestation. Moreover, in the cases in which we were inclined to suspect the presence of hookworm anæmia the improvement in the blood picture and general physical condition of the men must be interpreted with considerable caution, as we shall show by the cases of two uninfected men. It must be borne in mind that nearly all the men studied were drawn from the lower walks of life and presented the familiar undernourished condition that is characteristic of natives of Malaysia. In the group of nine men, protocols of whose cases we shall give below, eight were laborers.

All these men, before entering the prison, lived on the staple diet of the country—fish and rice—and probably not too much of either. It is scarcely necessary to add that their surroundings were insanitary and their manner of living distinctly unhygienic. Within the prison, however, their entire mode of life was changed. They received a simple but well-balanced ration, which included a liberal allotment of meat, in which most of them had not habitually indulged in the past. Their hours of work and rest were regular, and they were put through setting-up drills and allowed time for healthy recreation. Moreover, their surroundings were strictly sanitary. Under such circumstances it is a little difficult to make any general statement respecting the effects of treatment on men who originally were below par physically.

In illustration of this point we present the protocols of the two subjects who were not infested with hookworms.

Prisoner 13112.—Aged 48 years. Laborer. Symptoms of pulmonary tuberculosis. Microscopic examination before treatment showed ova of *Ascaris* and *Trichuris.* Blood examination before treatment: 4,220,000 erythrocytes; 80 per cent hæmoglobin. Blood examination 3 months 20 days after treatment: 4,750,000 erythrocytes; 95 per cent hæmoglobin. Weight advanced 2.2 kilograms. No worms were recovered on screening the stools after treatment. He received 8.7 cubic centimeters of carbon tetrachloride.

Prisoner 19189.—Aged 38 years. Laborer. Tubercular involvement of lungs. Microscopic examination before treatment showed ova of *Trichuris.* Blood examination before treatment: 4,950,000 erythrocytes; 65 per cent hæmoglobin. Blood examination 3 months, 16 days after treatment; 4,500,000 erythrocytes; 90 per cent hæmoglobin. Weight declined 2.2 kilograms. No worms were recovered on screening the stools after treatment. He received 6.9 cubic centimeters of carbon tetrachloride.

The following seven protocols are of subjects who were infested with hookworms:

Prisoner 14646.—Aged 18 years. Laborer. Personal history and physical examination yielded nothing of importance. Microscopic examination before treatment showed ova of hookworm and *Ascaris.* Blood examination before treatment: 5,040,000 erythrocytes; 80 per cent hæmoglobin; 18.5 per cent eosinophiles. Blood examination 3 months 16 days after treatment: 5,000,000 erythrocytes; 97 per cent hæmoglobin; 3.5 per cent eosinophiles. Weight advanced 0.9 kilogram. On screening the stools after treatment 9 *Necator* and 4 *Ascaris* were recovered. He received 7.5 cubic centimeters of carbon tetrachloride.

Prisoner 14658.—Aged 34 years. Merchant. Personal history and physical examination yielded nothing of importance. Blood examination 3 months, 10 days after treatment: 5,000,000 erythrocytes; 100 per cent hæmoglobin; eosinophiles not counted. Weight declined 5.6 kilograms. On screening the stools after treatment 1 *Ancylostoma,* 354 *Necator,* and 9

Ascaris were recovered. He received 10.4 cubic centimeters of carbon tetrachloride.

Prisoner 14764.—Aged 35 years. Laborer. Personal history and physical examination unimportant, except for a kyphosis. Blood examination before treatment: 4,300,000 erythrocytes; 78 per cent hæmoglobin; 4 per cent eosinophiles. Blood examination 3 months, 11 days after treatment: 4,950,000 erythrocytes; 95 per cent hæmoglobin; 22 per cent eosinophiles. Weight remained stationary. On screening the stools after treatment 20 *Ancylostoma*, 24 *Necator*, and 43 *Trichuris* were recovered. He received 9.1 cubic centimeters of carbon tetrachloride.

Prisoner 57340.—Aged 45 years. Laborer. Personal history unimportant. Physical examination developed that there was prolonged expiration over both sides posteriorly; impaired resonance of the right lower posteriorly. Many fine crepitant râles at the right lower. Blood examination before treatment: 3,500,000 erythrocytes; 87 per cent hæmoglobin; 11 per cent eosinophiles. Blood examination 2 months, 16 days after treatment: 4,150,000 erythrocytes; 90 per cent hæmoglobin; eosinophiles not counted. Weight advanced 2.9 kilograms. On screening the stools after treatment no adult hookworms were recovered. The fæces, however, contained numerous hookworm larvæ which presumably had hatched from ova present in the fæces before treatment, for no ova were found in his stool 2 months and 16 days after treatment.[2] He received 7.1 cubic centimeters of carbon tetrachloride.

At a second physical examination, two and one-half months after treatment, this man's lungs were clear on percussion and auscultation.

Obviously, this man was very lightly infected with hookworm. An accompanying infection with *Trichuris* likewise was very light, for it was only detected on concentration of the fæces. It seems unlikely, therefore, that his anæmia was the product of a helminthiasis, and his general improvement in health would seem to have been the result of the improvement in his mode of life that took place when he entered prison.

Prisoner 57342.—Aged 41 years. Laborer. Personal history and physical examination unimportant. He was, however, profoundly parasitized. He harbored, in addition to hookworm, *Ascaris, Trichuris, Entamœba histolytica,* and *E. coli.* Blood examination before treatment: 4,850,000 erythrocytes; 58 per cent hæmoglobin; 11 per cent eosinophiles. Blood examination 2 months, 15 days after treatment: 5,550,000 erythrocytes; 95 per cent hæmoglobin; 33 per cent eosinophiles. Weight advanced 1.8 kilograms. On screening the stools after treatment 6 *Ancylostoma* and 142 *Necator* were recovered. He received 7.6 cubic centimeters of carbon tetrachloride.

On reëxamination of the fæces of this man, two and one-half months after treatment, he was found still to be infected with

[2] This is of passing interest as indicating that hookworm ova and, possibly, sheathed larvæ are impervious to the action of carbon tetrachloride.

hookworm, *Trichuris*, and both of the amœbæ. We consider it likely that the elevation of his eosinophilia from 11 to 33 per cent was an expression of a cumulative effect, resulting from the persistence of his hookworm infection. A similar condition is presented by the next case.

Prisoner 57345.—Aged 36 years. Laborer. Personal history and physical examination not significant. Blood examination before treatment: 3,900,000 erythrocytes; 35 per cent hæmoglobin; 9.5 per cent eosinophiles. Blood examination 2 months, 15 days after treatment: 4,730,000 erythrocytes; 90 per cent hæmoglobin; 31 per cent eosinophiles. Weight advanced 4.7 kilograms. On screening the stools after treatment, 32 *Ancylostoma*, 271 *Necator*, and 1 *Trichuris* were recovered. He received 6.2 cubic centimeters of carbon tetrachloride.

Like the preceding subject, this man's fæces still contained ova of hookworm and *Trichuris* on examination, two and one-half months after treatment. His eosinophilia had increased from 9.5 per cent to 31 per cent; but, as shown above, he had increased substantially in weight.

Prisoner 14726.—Aged 30 years. Laborer. Personal history and physical examination irrelevant. Blood examination before treatment: 4,050,000 erythrocytes; 45 per cent hæmoglobin; 1.5 per cent eosinophiles. Blood examination 2 months, 3 days after treatment: 5,700,000 erythrocytes; 95 per cent hæmoglobin; 12 per cent eosinophiles. Weight declined 4.4 kilograms. On screening the stools after treatment 23 *Ancylostoma* and 77 *Necator* were recovered. He received 8.9 cubic centimeters of carbon tetrachloride.

On reëxamination of the fæces of this subject, two months after treatment, he was found still to be infested with hookworm and *Trichuris*.

For the reasons already stated, we refrain from any detailed discussion of the weights of these and the other men in the series, but as a point of general interest we present a few figures in connection with the eighty-eight men who were weighed both before and after treatment.

Weights were taken after periods ranging from 2 months, 4 days to 3 months, 21 days after treatment.

A gain in weight was recorded in fifty subjects, and a loss in thirty. Eight of the men showed no change in weight.

The maximum increase in weight, 10.4 kilograms, was recorded in a man who was infected with hookworm, *Ascaris*, and *Trichuris*. When examined before treatment, on June 22, 1922, his chest revealed crepitant râles and impaired resonance. His condition was unchanged on September 1.

The maximum loss in weight, 9.1 kilograms, was in a man who showed no evidence of tuberculosis during the time he was under our observation. He showed no abnormal reaction to the drug beyond the passage of considerable bile and mucus in his stool. This man presented a waxy, diabetic appearance. He had a soft, fixed tumor mass, about the size of a hen's egg, in the left lumbar region, about the level of the fourth lumbar vertebra.

VASCULAR SYSTEM

Pulse rate and blood pressures were taken before treatment, at the time the physical examination was made, and again one hour after the administration of the drug while the men still were partially under its effects. Nothing of especial significance was noted by us, but we feel that a careful study of the cardiovascular system during treatment with carbon tetrachloride is needed to make the picture complete. This of course should be made with care, to avoid the fallacies that creep into such work when it is undertaken under routine conditions.

No subjects were encountered in the series who gave any evidence of serious cardiac lesion. Physical examination, however, disclosed four with minor affections of the heart. These were prisoners 14643, who showed a soft systolic murmur, best heard over the mitral region; 57342, with a roughened first sound which was absent three months after treatment; 14710, with an occasional reduplication of the second sound, which likewise had disappeared three months later; and, 19369, with a short mitral systolic murmur, best heard over the second interspace left transmitted toward the left axilla.

APPEARANCE OF WORMS IN STOOLS AFTER TREATMENT

One of the most striking things noted in connection with the treatment was the promptness with which the hookworms were eliminated after treatment. Inspection of the figures at the conclusion of the work disclosed that 97 per cent of the hookworms recovered on screening were passed within the first twenty-four hours after treatment. This, however, was not the case with either *Ascaris* or *Trichuris*. Only 54 per cent of the total number of *Ascaris* recovered were found in the first twenty-four hours, and only 19 per cent of *Trichuris* recovered came down in that time. The greater number of *Trichuris* was expelled on the second day.

To determine how soon worm findings could be made after treatment, six men were treated on the basis of 1 cubic centimeter

of carbon tetrachloride to each 6 kilograms of body weight. The men were watched, and the first stool passed by each was sent to the laboratory for screening. The drug was administered at 1.40 o'clock in the afternoon. Every man in the group had defecated before 2.45 o'clock. The results are shown in Table 16. It will be seen that 17 per cent of the hookworms were eliminated in the first stool.

TABLE 16.—*Stool findings in six cases one hour after treatment.*

Prisoner No.—	Worms recovered.		
	First stool.	Add first day.	Second day.
14674	None	44 hookworms; 10 *Trichuris*	0
14675	17 hookworms; 1 *Ascaris*	13 hookworms; 1 *Trichuris*	0
14676	3 hookworms	19 hookworms; 2 *Trichuris*	53 *Trichuris.*
14677	13 hookworms; 1 *Ascaris*; 2 *Oxyuris.*	76 hookworms; 90 *Oxyuris*	0
14678	2 *Ascaris*; 1 *Oxyuris*	1 hookworm; 4 *Ascaris*	0
14679	2 *Oxyuris*	2 hookworms; 1 *Ascaris*; 9 *Oxyuris.*	0

The findings on screening the stools of the hookworm-positive cases are shown in Table 17. These are recorded day by day, together with the amount of drug administered. It will be seen that there appears to be no correlation whatever between the quantity of carbon tetrachloride administered and the proportionate number of worms recovered on the first day.

Of the total number of worms passed by these men in the stools collected during the three days succeeding treatment, 97 per cent were contained in the stools passed during the first twenty-four hours. In fact, 63 per cent of the men seemed to have unburdened themselves of their total stock of worms in this time, for none were found on the subsequent days. In only two instances did we recover worms from stools passed on the third day. The stools of seven men were negative throughout. It has been noted that the lightly infected cases seem to be the more difficult to clear. It is highly probable that these cases were lightly infected and that the worms were passed either in a condition of extreme maceration, or were lost in particularly bulky stools, of which there were many. Prisoners are fed unpolished rice at Bilibid, and the stools are usually full of husks which add great difficulties to the search for worms.

The dosages of carbon tetrachloride administered to the subjects from whom we failed to recover hookworms on screening ranged from 6.6 to 11.2 cubic centimeters.

TABLE 17.—*Number of hookworms recovered each day after treatment.*

Prisoner No.—	Carbon tetrachloride given.	Worms recovered.		
		First day.	Second day.	Third day.
	cc.			
14707	9.5	78	0	0
14708	11.3	91	0	0
14709	10.3	5	0	0
14710 [a]	11.2	0	0	0
14711	8.3	4	0	0
14712	9.3	26	0	0
14713	10.0	25	0	0
14714	9.0	2	0	0
14715	10.8	21	0	0
14717	10.0	16	0	0
14718	12.0	43	0	0
14719	9.4	9	0	0
14721	11.1	7	0	0
14722	10.8	2	0	0
14723	9.4	9	0	0
14724	9.4	7	0	0
14725	10.8	29	1	0
14726	8.9	99	1	0
14727	10.8	74	3	0
14728	9.2	24	0	0
14729	9.2	46	0	0
14730	9.2	22	0	0
14731	8.7	37	0	0
14733	11.6	10	0	0
19366	11.7	96	1	0
19367	9.3	14	1	0
19369	9.8	2	10	0
19370	8.7	3	9	0
14966	8.7	24	0	0
14969	12.5	24	0	0
15001	10.4	14	0	0
58762	10.0	90	8	0
14641	8.9	68	1	0
14642	10.8	107	11	0
14646	7.5	9	0	0
19180	10.8	7	1	0
19188	7.3	12	0	0
57127	11.4	22	1	0
57129 [a]	9.4	0	0	0
57140	7.1	10	2	0
14654	9.9	23	0	0
14656	8.3	0	2	0
14657	10.0	4	27	0
14658	10.4	356	0	0
14659	8.6	244	0	0
14660	10.0	36	2	0
14661	9.9	23	0	0
14662	8.0	70	0	0

[a] No worms were recovered on screening the stools.

TABLE 17.—*Number of hookworms recovered each day after treatment*—Continued.

Prisoner No.—	Carbon tetrachloride given.	Worms recovered.		
		First day.	Second day.	Third day.
	cc.			
14663	8.9	10	0	0
14664	8.9	4	0	0
14666 [a]	6.6	0	0	0
14667	9.0	9	0	0
14668	8.3	73	0	0
14669	9.3	6	0	0
14670	8.5	24	0	0
14671	9.8	8	0	0
14672	8.5	7	0	0
14673	9.1	19	0	0
14674	9.1	44	0	0
14675	12.5	13	0	0
14676	8.9	19	0	0
14677	8.3	76	0	0
14678	11.9	1	0	0
14679	8.7	2	0	0
14680	8.4	154	0	0
14681 [a]	9.0	0	0	0
14682	6.6	1	1	0
14683	8.3	3	0	0
14684 [a]	6.6	0	0	0
14685	9.4	11	0	0
14686	7.5	27	0	0
14687	9.4	2	0	0
14689	7.6	70	2	1
14690	8.7	14	2	0
14691	9.0	17	0	0
14692	6.2	16	0	0
14693	7.1	9	0	0
14694 [a]	7.5	0	0	0
14695	6.2	2	0	0
14702	8.1	121	0	0
14703	8.2	22	0	0
14704	7.6	13	0	0
14705	7.8	149	0	0
57340 [a]	7.1	0	0	0
57341	8.3	98	0	0
57342	7.6	148	0	0
57343	7.1	56	0	0
57345	6.2	301	1	1
57346	7.8	1	0	0

[a] No worms were recovered on screening the stools.

The foregoing data shed no definite light as to whether *Ancylostoma duodenale* is or is not more resistant to the action of carbon tetrachloride than is *Necator americanus.* The fact re-

mains, however, that only 30 per cent of the worms expelled after the first day were *Ancylostoma*. In our judgment, it is not likely that any difference in response would be noticeable in the doses we administered, which are proportionately larger than those given by other investigators. Whether or not the high efficiency of the drug which led to the expulsion of 97 per cent of the total number of worms within the first twenty-four hours can be turned to account in the saving of time and labor in future surveys remains to be determined.

Carbon tetrachloride, as has been said, is not nearly so efficient a vermicide against *Ascaris* and *Trichuris* as it is against hookworm. Based on stool examination, not of itself entirely conclusive, we succeeded in clearing only five *Ascaris* and three *Trichuris* infestations. At the same time, we regard our results in the treatment of *Trichuris* infestation as somewhat encouraging, for it will be seen on scanning Table 19 that in several instances the drug brought about the expulsion of numerous worms, even though ova were found at a subsequent microscopical examination. In the treatment of subjects infested with *Ascaris* and *Trichuris*, we failed to recover *Ascaris* in eleven cases and *Trichuris* in sixty-three. In six instances we recovered *Ascaris* on screening the stools, only to find the ova on reëxamination. We likewise recovered *Trichuris* in eighteen cases, the ova being recoverėd on reëxamination.

This performance seemed to bear no relation whatever to the quantity of drug administered, as will be seen by inspection of Table 18, which sets forth the doses administered to eleven *Ascaris*-infected subjects from whom no adult worms were recovered after treatment.

TABLE 18.—*Quantity of carbon tetrachloride administered to eleven subjects infested with Ascaris, from whom no Ascaris were recovered.*

Prisoner No.—	Quantity of drug. cc.
19366	11.7
14709	10.3
14722	10.8
14724	9.4
14726	8.9
14731	8.7
14682	6.6
14704	7.6
57342	7.6
13112	8.7
14641	8.9

When the drug acts at all, it seems to act effectively, for nearly all the worms recovered within the first few hours after treatment were dead, the few that were recovered alive being moribund. This may in itself be a danger as leading to the retention of dead worms the presence of which in the intestinal tract may give rise to unpleasant symptoms, as is pointed out by Haughwout and Ash.(5)

The location of *Trichuris* in the large intestine is unfavorable as regards the application of the drug. The drug reaches the lower intestine in a state of dilution and at a time when peristalsis has been stimulated to a marked degree. The consequence is that it has little time to exert itself on the worms, but is hurried past them in a weakened concentration. The surprising thing is that it is as efficient as our figures show it to be in certain cases. We are led to suspect, though we have no definite data to support the supposition, that the cases in which it seemed to act most efficiently were afforded by patients whose bowels did not move so briskly or so promptly as did those of the other men. The observations on the cases of *Ascaris* and *Trichuris* infestation are recorded in Table 19.

TABLE 19.—*Results of treatment of Ascaris and Trichuris infestations.*

Case No.—	Dose.	*Ascaris.*			*Trichuris.*			Final stool examination.
		First day.	Second day.	Third day.	First day.	Second day.	Third day.	
	cc.							
19366	11.7	0	0	0	0	0	0	Not done.
19367	9.3	2	1	0	0	0	0	Do.
19369 [a]	9.8	------	------	------	0	0	0	Do.
19370 [a]	8.7	------	------	------	0	0	0	Do.
14966	8.7	2	0	0	0	3	0	Do.
14969 [b]	12.5	1	0	0	------	------	------	Do.
15001 [b]	10.4	0	3	0	------	------	------	Do.
58762 [b]	10.0	3	1	0	------	------	------	Do.
14707 [a]	9.5	------	------	------	0	0	0	Negative.
14708 [a]	11.3	------	------	------	0	0	0	*Trichuris* +.
14709	10.3	0	0	0	0	0	0	Do.
14710	11.2	0	0	0	3	0	0	Do.
14711	8.3	4	0	0	0	0	0	Do.
14712	9.3	3	0	0	0	0	0	Do.
14713 [a]	10.0	------	------	------	0	0	0	Do.
14714 [a]	9.0	------	------	------	0	0	0	Negative.
14715	10.8	8	0	0	0	0	0	*Trichuris* +.
14717 [a]	10.0	------	------	------	0	0	0	Negative.
14718 [a]	12.0	------	------	------	0	1	0	*Trichuris* +.
14719	9.4	1	0	0	1	0	0	Do.

[a] Not infested with *Ascaris*. [b] Not infested with *Trichuris*.

TABLE 19.—*Results of treatment of Ascaris and Trichuris infestations*—Continued.

Case No.—	Dose.	*Ascaris.* First day.	*Ascaris.* Second day.	*Ascaris.* Third day.	*Trichuris.* First day.	*Trichuris.* Second day.	*Trichuris.* Third day.	Final stool examination.
	cc.							
14721	11.1	1	0	0	0	0	0	*Ascaris* +, *Trichuris* +.
14722	10.8	0	0	0	0	0	0	*Trichuris* +.
14723	9.4	1	23	0	7	27	0	Negative.
14724	9.4	0	0	0	18	1	0	*Trichuris* +.
14725	10.8	3	0	0	0	0	0	Do.
14726	8.9	0	0	0	0	0	0	Do.
14727	10.8	3	1	0	0	0	0	Do.
14728	9.2	13	4	0	0	0	0	Do.
14729	9.2	4	0	0	3	0	0	Negative.
14730	9.2	2	0	0	0	0	0	*Trichuris* +.
14731	8.7	0	0	0	0	0	0	Do.
14733	11.6	6	1	0	0	0	0	Do.
14680	8.4	0	1	0	0	0	0	Do.
14681	9.0	0	1	0	0	0	0	Do.
14682	6.6	0	0	0	0	0	0	Do.
14683 [c]	8.3	0	3	0	0	0	0	Do.
14684 [c]	6.6	0	3	0	0	0	0	Do.
14685 [a]	9.4	------	------	------	0	0	0	Negative.
14686 [a]	7.5	------	------	------	1	40	0	*Trichuris* +.
14687	9.4	------	------	------	0	2	0	Do.
14689 [c]	7.6	------	[d] 1	------	0	0	0	Negative.
14691 [e]	9.0	1	0	0	0	4	0	Do.
14692 [b]	6.2	4	7	0	------	------	------	*Ascaris* +.
14693	7.1	1	0	0	0	0	0	*Trichuris* +.
14694 [a]	7.5	------	------	------	0	0	0	Do.
14695 [c]	6.2	2	0	0	0	0	0	Do.
14702	8.1	4	0	0	0	0	0	Do.
14703 [a]	8.2	------	------	------	0	0	0	Negative.
14704	7.6	0	0	0	0	0	0	*Ascaris* +, *Trichuris* +.
14705	7.8	2	1	1	0	0	0	*Trichuris* +.
57340 [a]	7.1	------	------	------	0	0	0	Do.
57342	7.6	0	0	0	0	0	0	Do.
57343	7.1	2	0	0	0	0	0	Not done.
57345 [a]	6.2	------	------	------	0	0	1	*Trichuris* +.
57346	7.8	7	0	1	0	0	0	Do.
14654 [a]	9.9	------	------	------	0	1	0	Do.
14656 [a]	8.3	------	------	------	0	0	0	Do.
14657	10.0	6	1	0	0	0	0	Do.
14658	10.4	9	0	8	0	0	1	Do.
14659	8.6	2	2	0	0	0	0	Do.
14660	10.0	7	0	0	0	1	0	Do.

[a] Not infested with *Ascaris.*
[b] Not infested with *Trichuris.*
[c] *Ascaris* ova not found on first examination.
[d] Immature worm.
[e] *Trichuris* ova not found on first examination.

TABLE 19.—*Results of treatment of Ascaris and Trichuris infestations*—Continued.

Case No.—	Dose.	*Ascaris.* First day.	*Ascaris.* Second day.	*Ascaris.* Third day.	*Trichuris.* First day.	*Trichuris.* Second day.	*Trichuris.* Third day.	Final stool examination.
	cc.							
14661 [c]	9.9	0	1	0	0	0	0	*Trichuris* +.
14664 [a]	8.9	------	------	------	0	0	0	Do.
14666 [a]	8.6	------	------	------	0	0	0	Do.
14669 [a]	9.0	------	------	------	0	0	0	Do.
14668 [a]	8.3	------	------	------	1	7	1	Negative.
14669	9.3	4	0	0	1	2	0	*Trichuris* +.
14670	8.5	10	0	0	0	0	0	Do.
14671	9.8	7	0	0	2	2	1	*Ascaris* +, *Trichuris* +.
14672 [a]	8.5	------	------	------	0	1	0	*Trichuris* +.
14673	9.1	9	1	2	11	15	43	*Trichuris* +, heavy.
14674 [a]	9.1	------	------	------	10	33	0	*Trichuris* +.
14675 [c]	12.5	[f] 1	0	0	0	1	0	Do.
14676	8.9	0	0	0	2	53	0	*Ascaris* +, *Trichuris* +.
14678	11.9	4	0	0	0	0	0	*Trichuris* +.
11389 [a]	8.8	------	------	------	0	0	0	Do.
13112	8.7	0	0	0	0	0	0	Negative.
14579	8.1	0	3	0	0	0	0	Do.
14641	8.9	0	0	0	0	0	0	*Trichuris* +.
14642	10.8	24	2	0	0	0	0	Do.
14634 [c]	8.3	1	0	0	0	0	0	Do.
14646 [b]	7.5	4	0	0	------	------	------	Do.
19174	8.8	6	0	0	0	0	0	Do.
19180	10.8	2	0	0	0	0	0	Do.
57600	8.1	5	0	0	0	0	0	Do.
19188 [a]	7.3	------	------	------	0	0	0	Do.
19189 [a]	6.9	------	------	------	0	0	0	Do.
56471 [c]	7.7	1	0	0	0	0	0	Do.
57112	8.0	0	11	0	0	3	0	Do.
57127	11.4	3	0	0	0	0	0	*Ascaris* +, *Trichuris* +.
57128 [a]	8.9	------	------	------	0	0	0	*Trichuris* +.

[a] Not infested with *Ascaris.*
[b] Not infested with *Trichuris.*
[c] *Ascaris* ova not found on first examination.
[f] Male worm.

To summarize: It will be seen by Table 19 that 54 per cent of the total number of *Ascaris* recovered after treatment were passed within the first twenty-four hours, and 75.3 per cent during the first two days. Twenty-eight men passed no *Ascaris* after the first day; eighteen, none after the second day; and only four passed *Ascaris* on the third day.

In the case of *Trichuris,* however, only 19 per cent of the total number of worms recovered were passed the first day, but the percentage had risen to 84.5 the second day. Subjects who passed no *Trichuris* after the first day numbered only three, and fifteen passed none after the second day. Five subjects yielded *Trichuris* on the third day.

This makes it clear that the drug is not devoid of efficiency against both species. The apparent delay in the reaction of the drug against *Trichuris* is interesting, and it is not unlikely that it is slightly more efficient than our figures show. It must be borne in mind that *Trichuris* implants itself much more firmly in the intestinal wall than do any of the other species of nematodes and, while many of the worms may be killed by treatment, their appearance in the fæces may be delayed until maceration progresses to the point where they break off along the course of the relatively thin "neck," at or near the point of penetration into the mucosa. It seems to us more likely that this furnishes the explanation for this phenomenon rather than a supposedly cumulative effect of the drug itself.

OCCUPATIONAL DISTRIBUTION OF WORM COUNTS

Though this phase of the hookworm problem is outside of the scope of this paper, it seems not inappropriate to record the distribution of worm counts with relation to the occupations of the several men. Summarizing the worm counts for the entire series, it is seen that 3,539 hookworms were recovered after treatment. Of this number, 2,929 were *Necator americanus* and 610 *Ancylostoma duodenale.* The men, as has been said, were drawn from widely separated portions of the Archipelago and to a certain degree may be said to be fairly representative of the Philippine Islands as a group. This yields a rather high ancylostoma index, 17.2, thus fulfilling the prediction of Haughwout(4) that *Necator americanus* probably would be shown to be the dominant species in the Philippines, but that the ancylostome index might be fairly high.

By far the greater number of our subjects were registered on the prison records as laborers, but there is reason to doubt that the records regarding occupation as given to the prison authorities were in all instances correct. For instance, we found that a chief of police from Cebu Province harbored 154 worms, while a "merchant" from Sorsogon yielded 355. We are inclined to believe that the chief of police either did not wear his full equipment at all times or that he was engaged in some

agricultural occupation on the side. We also doubt if our "merchant" spent a great deal of time in his counting house. However, we think that the allotment of seventy-two men to the class of laborers is substantially correct. Sixty-seven of these men were infested with hookworms.

On screening the stools of these men, we recovered 2,546 hookworms, of which 2,070 were *Necator americanus* and 476 *Ancylostoma duodenale.* Only 2 pure *Ancylostoma* infestations were found, while there were 20 pure *Necator* infestations. We failed to recover worms from the stools of six men.

The worm counts in the various groups are presented in Tables 20, 21, and 22. They are correlated with the age and place of residence of each man. We believe it would be unprofitable at this time to discuss the occupational incidence in this series, for proper interpretation of the figures presupposes fuller information regarding local soil and meteorologic conditions than is yet in our possession. Certain anomalies in our tables will be quite apparent to those familiar with the occupational phases of hookworm survey work.

TABLE 20.—*Hookworm counts on laborers in relation to age and provincial residence.*

Prisoner No.	Age.	Province.	*Ancylostoma.*	*Necator.*	Total.
	Years.				
14708	33	Albay	0	91	91
14686	52	Antique	14	12	26
14687	58	do	0	2	2
14661	48	Batangas	0	18	18
14662	31	do	2	68	70
14663	26	do	0	10	10
14664	26	do	0	4	4
57127	26	Bohol	1	22	23
14725	45	Cagayan	8	22	30
14726	30	do	23	77	100
14727	27	do	27	40	67
14728	19	do	5	19	24
14730	32	do	2	20	22
14731	27	do	16	21	37
14733	43	do	6	4	10
14677	23	Cebu	19	57	76
14678	32	do	0	1	1
14679	26	do	0	2	2
14681	24	do	0	0	0
14689	37	Ilocos Norte	10	62	72
14690	32	do	2	14	16
14691	37	do	5	12	17
14692	38	do	3	13	16
14729	20	do	9	37	46

TABLE 20.—*Hookworm counts on laborers in relation to age and provincial residence*—Continued.

Prisoner No.—	Age.	Province.	*Ancylostoma.*	*Necator.*	Total.
	Years.				
14682	42	Ilocos Sur	0	2	2
14683	32	do	3	0	3
14693	48	Isabela	0	9	9
14694	30	do	0	0	0
14695	38	do	0	2	2
14685	29	Laguna	0	11	11
14702	56	Leyte	11	110	121
14703	45	do	6	16	22
14704	23	do	1	12	13
14705	17	do	12	137	149
57340	45	do	0	0	0
57341	19	do	36	62	98
57342	41	do	6	142	148
57343	23	do	19	37	56
57345	36	do	32	271	303
57346	23	do	0	1	1
14646	18	Manila	0	9	9
57140	17	do	0	12	12
14642	26	Misamis	32	86	118
14684	36	Mountain	0	0	0
14668	25	Occidental Negros	39	34	73
14670	17	do	4	20	24
14671	25	do	2	6	8
14672	40	do	0	7	7
14673	42	do	1	18	19
14674	35	do	20	24	44
14675	64	do	0	13	13
14676	38	do	10	9	19
14966	32	do	14	10	24
58762	20	do	17	81	98
14969	31	Nueva Ecija	15	9	24
14717	26	do	6	10	16
14666	30	Palawan	0	0	0
14667	19	do	0	9	9
14709	21	Pampanga	5	0	5
19180	22	Panay	2	6	8
14710	45	Pangasinan	0	0	0
14711	25	do	2	2	4
14713	38	do	9	16	25
14714	25	do	0	2	2
14715	53	do	20	1	21
14722	37	Samar	0	2	2
14659	37	Sorsogon	0	244	244

SUMMARY

Our study of the action of carbon tetrachloride in various dosages, on a group of one hundred male Filipinos in Bilibid Prison, has led to findings that we regard as fairly definite. These

TABLE 21.—*Hookworm counts in relation to occupation, age, and provincial residence.*

Prisoner No.—	Age.	Province.	Occupation.	*Ancylostoma.*	*Necator.*	Total.
14641	28	Cavite	Farmer	4	65	69
19369	26	Nueva Ecija	do	7	26	33
19366	59	Pangasinan	do	49	38	87
19367	35	do	do	14	1	15
19370	70	do	do	5	7	12
14719	19	Tayabas	Carpenter	1	8	9
57129	31	Misamis	do	0	0	0
14660	22	Sorsogon	Employee	0	38	38
14721	37	Samar	do	0	7	7
14664	25	Cuyo	Barber	0	4	4
14707	29	Albay	do	0	78	78
14669	21	Jolo	Foreman	1	5	6
14680	28	Cebu	Chief of police	8	146	154
14712	33	Pangasinan	Mechanic	0	26	26
14718	23	Tayabas	Lavandero	11	32	43
14654	47	Laguna	Proprietor	1	22	23
14656	31	Sorsogon	Soldier	0	2	2
14657	20	do	Messenger	4	27	31
14658	34	do	Merchant	1	354	355
14723	37	Cagayan	Clerk	7	2	9
14724	33	do	Sailor	3	4	7
15001	?	(?)	Unknown	10	4	14
19188	26	Rizal	Agent	10	2	12

TABLE 22.—*Distribution of subjects according to occupation.*

Occupation.	Total.	Infected with hookworm.
Laborer	72	67
Farmer	5	5
Student	1	1
Lavandero	1	1
Clerk	1	1
Foreman	1	1
Treasurer	1	0
Employee	2	2
Proprietor	2	1
Barber	2	2
Agent	1	1
Mechanic	1	1
Stenographer	1	0
Boxer	1	0
Carpenter	2	2
Soldier	1	1
Sailor	1	1
Messenger	1	1
Merchant	1	1
Chief of police	1	1
Unknown	1	1

findings have been conclusively checked and confirmed, so far as concerns the dosage, by the treatment of more than 25,000 Filipinos of all ages and both sexes as well as in varying conditions of disease and health, by the heaviest dosages we have employed in this series.

Not only have there been no fatalities, but in no instance has a subject shown a physical reaction to the drug that has necessitated treatment or has given the slightest cause for anxiety on the part of those who administered it.

We attribute our immunity from such mishaps to the observance of three fundamental principles.

1. The administration of a drug of known purity as attested by chemical examination and purification. In no instance have we accepted the word of the manufacturer with respect to the purity of the drug.

2. The rejection of all persons showing obvious pathology of the liver,[3] and serious lesion of the heart or urinary system.

3. The rejection of all acute alcoholic subjects, and the withdrawal of alcohol for a period of days prior to treatment from all subjects who indulged in it to even a moderate degree.

Our maximum dosages were computed on the basis of data obtained by the administration of maximum doses to three condemned murderers, and finally checked by the anatomical and histological examinations of the organs of a man who was executed three days after taking a maximum dose. We failed to find any evidence of drug intoxication in this case.

Observations made before, during, and after the treatment of these one hundred men has yielded us information that we summarize as follows:

BLOOD AND VASCULAR SYSTEM

Blood.—Few significant data were obtained by study of the blood. Many cases showed a polycythæmia and high hæmoglobin percentage before treatment. No changes were noted in these that could be attributed to the direct action of the drug. In many cases there was a tendency toward a transient elevation in the proportionate number of polymorphonuclear neutrophiles. The behavior of the eosinophiles was erratic, and no general conclusions can be drawn.

Vascular system.—Our studies on the pulse and blood pressure yielded us no information on which we care to base conclusions.

[3] It will be recalled that we treated one man who was jaundiced without, however, observing any untoward effects.

This is a phase of the action of the drug that should be given further study.

Heart.—No untoward cardiac symptoms were noted during treatment, even in cases showing slight cardiac irregularities.

RESPIRATORY AND NERVOUS SYSTEMS

Nothing was observed that could be attributed to the direct action of the drug.

URINARY SYSTEM

Beyond the transient appearance of casts after treatment we secured no evidence of irritant action of the drug on the kidneys; this notwithstanding we administered it to subjects showing a mild degree of renal disturbance.

DIGESTIVE SYSTEM

Our observations yielded us abundant evidence that carbon tetrachloride exerts a stimulative action upon the liver. We observed nothing, however, that led us to suspect that this effect is more than transient under the doses administered by us. This effect was made evident through a hypersecretion of bile in the stools in many instances and, in one instance, possibly, by the discovery of bile in the urine of a subject twenty-four hours after treatment. In no instance was complaint made of pain or tenderness referred to the liver.

The drug also has an irritant effect on the intestinal tract; although few subjects complained of distress. This is expressed by the production, in some cases, of rather excessive quantities of mucus, sometimes accompanied by abdominal pain. The relations of these phenomena to the quantity of drug taken are not very constant. The hypersecretion of both bile and mucus may persist for two or three days, but usually it subsides within twenty-four hours after the administration of the drug.

On the basis of the foregoing and other observations we have made, we are led to conclude the following:

CONCLUSIONS

The same care should be exercised in prescribing carbon tetrachloride as is observed in the administration of any potent drug that may work harm in the presence of contraindications or in excessive quantities. In other words, *it always should be given under competent medical supervision.*

Doses of *pure* carbon tetrachloride, computed on the basis of 1 cubic centimeter of the drug to each 5.5 kilograms of body weight, are safe in the absence of the contraindications we have

mentioned. On this basis, we have administered doses ranging up to 12.5, and even 15 cubic centimeters, without observing untoward effects of a serious nature.

We do not, however, maintain that this should be the standard dose. Our studies have yielded us abundant evidence that smaller proportions are equally efficient in the removal of hookworms and a certain proportion of other intestinal helminths.

Existing infection with *Entamœba histolytica,* provided there is no active dysenteric process, or previous infectious disease of the intestinal tract is not a contraindication provided no active process is present.

Several men showing definite pathology of one kind or another were treated on the same basis as the other men. Their defects included tuberculosis; splenic and liver enlargement, probably of malarial origin; slight renal disturbance; and valvular heart lesions. There was a total lack of significance in the reactions to the drug shown by these men. Their behavior as a group, and individually, in no way differed from that of the group of men in whom we found no physical defects.

Moderate alcoholism is not a contraindication to the administration of carbon tetrachloride, provided liquor is withheld from the men two or three days before and after treatment. Untoward effects in alcoholic subjects usually can be attributed to disregard of this rule. Statistically, the men in this series who admitted the use of alcohol showed less abnormal reaction to the drug than did those who denied the use of alcohol.

Saline purgatives should not be given immediately before treatment, for they apparently reënforce the irritative properties of the drug on the intestinal mucosa.

We consider that the administration of the drug in divided doses is both unnecessary and undesirable.

Carbon tetrachloride is without effect upon any of the common intestinal protozoa. Its administration in protozoal infections of the intestinal tract, therefore, is irrational.

Although observations have not been made on this in the work recorded here, we consider it opportune to voice our opinion that the drug should not be given during the course of any infectious disease where the heart and liver are already overburdened by a toxæmia. This applies with particular force to acute intestinal affections, and to infectious abdominal (surgical) conditions such as peritonitis. Cases may arise where it is desirable to rid a surgical patient of a hookworm infestation. In such cases, the circumstances should be made the subject of

very careful inquiry. In our opinion, the drug should be administered several days before the administration of an anæsthetic, in order that the liver may entirely recover from the stimulating effects of the carbon tetrachloride. This we deem especially important if it is desired to administer chloroform.

Among the subjects for future investigation that are suggested by our work we may mention the following: Is the administration of the drug to persons about to undergo surgical operation fraught with any dangers? Are untoward hepatic symptoms likely to arise when an anæsthetic is later administered? Would there be a tendency toward the development of ileus? Do any racial idiosyncracies to the drug exist? How is the drug eliminated? What are the effects of the drug on the cardio-vascular system? Definitely, what is the action of this drug on *Trichuris?*

Lastly, further pathologic work should be done with especial attention to the kidneys and liver. Such studies should be made with strict attention to the prevalence of mild to subacute conditions commonly found in the kidneys and livers of natives of tropical countries, which not improbably bear a more or less definite relation to the prevailing intestinal pathology in these people. Lesions of the liver should be studied with an eye to the topographic relations of the microscopic lesions.

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ILLUSTRATION

PLATE 1

FIG. 1. Portal area.
2. Hepatic-vein area.

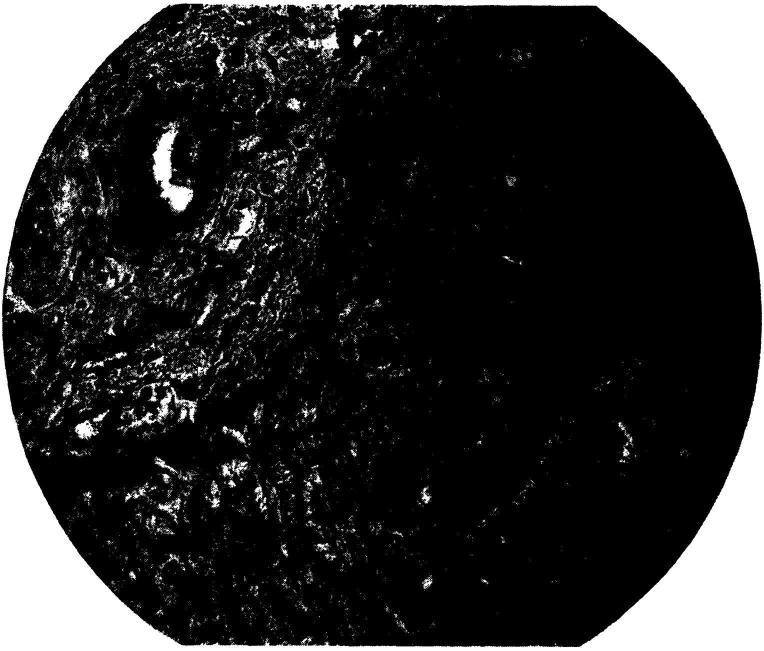

Fig. 1. Portal area.

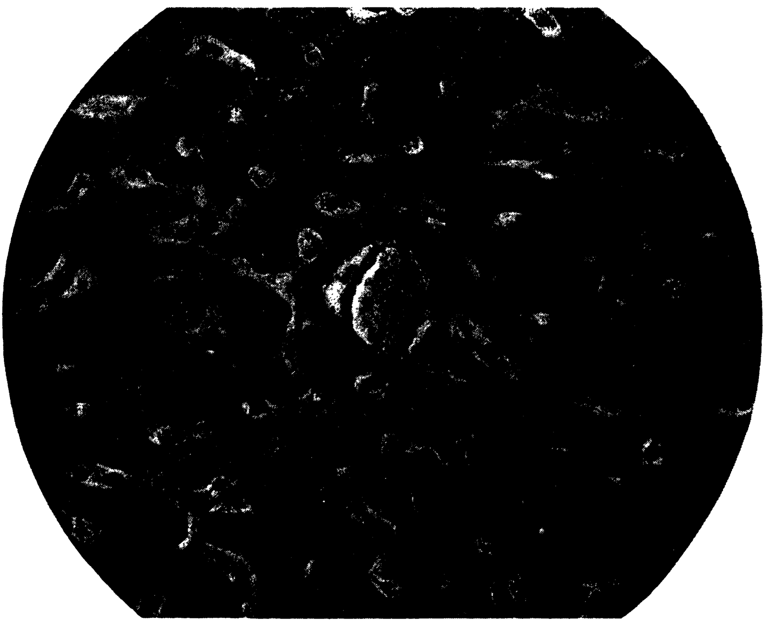

Fig. 2. Hepatic-vein area.

PLATE 1.

PRELIMINARY REPORT ON CREOSOTE AS AN ADJUVANT IN LEPROSY TREATMENT [1]

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TWO TEXT FIGURES

INTRODUCTION

Points of similarity or resemblance between tuberculosis and leprosy make it seem reasonable that any feature of treatment useful in the former disease may prove of value in the latter. However, it is obvious that this would not necessarily be the case, though Muir [2] was led to express the converse opinion that the effective antileprosy treatments are among the best for tuberculosis. Therefore, before applying on a large scale to leprosy treatment any drug accepted as useful in tuberculosis, its value in the former disease should be established or at least clearly indicated.

Muir, after using Rogers's sodium gynocardate and sodium morrhuate in treating lepers, introduced a mixture of chaulmoogra ethyl ester, 1 milliliter; creosote, 1 milliliter; camphor, 1 gram; and olive oil, 2.5 milliliters, which he refers to as E. C. C. O. At the time the chaulmoogra ethyl esters were being tried in the Philippines in comparison with Rogers's and other preparations, as a result of which they were adopted as the best drug for routine treatment under existing conditions. At the same time (1921), the workers then at Culion tried, in a few cases of leprosy complicated with tuberculosis, a cod-liver oil modification of Muir's formula known here as M. C. C. O., with benefit, it seemed, to patients showing the primary infection. As it was a matter of considerable interest to determine definitely whether the addition of creosote to the routine ethyl ester preparation would give better results in treatment, we had become sufficiently interested in the matter to encourage us to carry

[1] Read before the Culion Medical Society, June 29, 1923. Published with the consent of the Director of Health and the approval of the Philippine Leprosy Research Board.

[2] Muir, E., Handbook on Leprosy. Cuttack, R. J. Grundy (1921) 63.

out a series of observations with this end in mind. The work done and the results obtained are set forth here.

TREATMENT GROUPS

For our purpose one hundred ninety-four patients of both sexes and of varying ages were selected. All had been treated for nearly a year, in different groups, all receiving for the last few months the plain (noniodized) chaulmoogra ethyl esters, and from all appearances they had improved to a greater or less extent as a result of the treatment.

The patients were divided into four main groups, an attempt being made to make these uniform so far as sex and age were concerned. The type and the duration of the disease and the extent of involvement of the tissues differed so widely that it was not considered advantageous to attempt to determine the groups on this basis. The cases were practically all of the cutaneous and mixed types, and moderately advanced, though on the average not to the point of being distinctly unfavorable for treatment. Each of us treated approximately one-half of each group, more or less independently.

The observation, at the time the data herein presented were obtained, had extended over a period of six months. Injections were given intramuscularly twice a week, except when for some reason or other injection was postponed.

The treatments used were as shown in Table 1.

TABLE 1.—*Treatments used.*

Group	Cases.	Treatment.
I	53	Chaulmoogra ethyl ester, intramuscularly.
II	49	C. E. E. intramuscularly, creosote by mouth.
III	43	C. E. E., creosote, and camphor mixture.
IV	49	C. E. E. and creosote mixture.

Group I, in which there was no change from the treatment previously given to all, served as the control. Group II was treated identically except that a pill containing 0.3 milliliter of creosote was given at each injection, totaling 0.6 milliliter of this drug per week when the patient took both treatments. The dose was made small in the desire to avoid gastric irritation. Group III was given injections of a solution with the formula chaulmoogra ethyl esters, 1,000 milliliters; creosote, 25 milliliters; camphor, 25 grams. The solution given Group IV differed from this in that no camphor was used and, after the first few injec-

tions, but 12.5 milliliters of creosote to 100 milliliters of the ethyl esters. The ordinary United States Pharmacopœia grade of creosote was used almost entirely on account of the cost of the beechwood variety.

DOSAGE

As all of the patients were accustomed to receiving injections of the plain ethyl esters, the dosage that it was found possible to give the different groups is a fair indicator of the irritation, local or distant, produced by each particular preparation.

In establishing the maximum tolerated dose the drug was pushed, being increased by 1 milliliter at a step to the point of production of untoward effects, either local or general; the next lower milliliter was taken as the amount tolerated by that patient. We have observed that on attempting subsequently to increase the dose beyond this point unfavorable effects were usually produced.

TABLE 2.—*Maximum tolerated dose of creosote.*

Group.	Cases.	Percentage receiving—				
		1 cc.	2 cc.	3 cc.	4 cc.	5 cc.
I	53	1.9	0	17.0	79.2	1.9
II	49	2.0	2.0	28.6	61.2	6.1
III	43	0	9.3	72.1	14.0	4.6
IV	49	2.0	4.1	63.3	30.6	0

The data given in Table 2 are plotted in fig. 1.

The similarity of the curves of Groups I and II, which received injections of plain esters, is striking, as is that of the curves of Groups III and IV, which received creosote-ester solutions. The difference between these two pairs of curves is of interest. From the dosage figures of Table 2 the following averages are obtained: Groups I and II, 3.8 and 3.7 milliliters, respectively; Groups III and IV, 3.1 and 3.2 milliliters.

Naturally, creosote taken by mouth in small doses (Group II) does not influence the total amount of the ethyl esters that can be given intramuscularly. On the other hand, it is apparent that the incorporation of creosote in the ethyl esters, at least in the concentrations used, does lessen the amount of the mixture that can be given without undesirable effects.

It is of interest that Group III could be given practically as large doses of the creosote-camphor solution (20 per cent of each) as could Group IV with approximately 11 per cent creo-

sote and no camphor. At the outset 20 per cent creosote without camphor was used in Group IV, but this was so irritating that the amount added to the 100 milliliters of ethyl esters was reduced to 10 cubic centimeters. The patients complained of pain during injection, and serious local inflammations developed subsequently. Therefore, it is clear that camphor in this combination does reduce irritation.

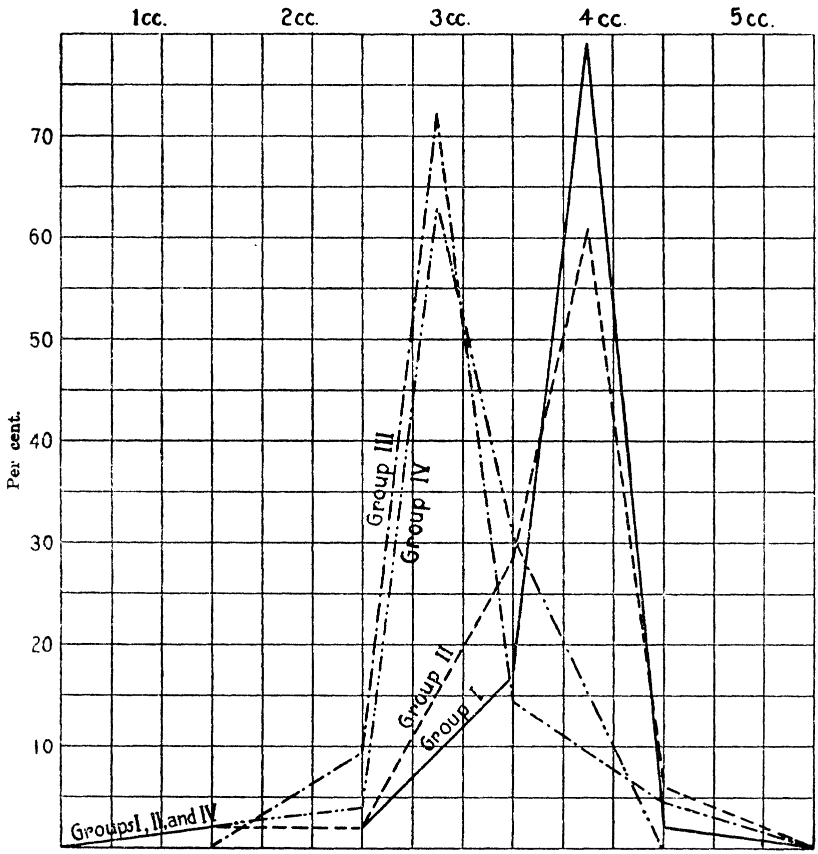

FIG. 1. The maximum tolerated dose of creosote in leprosy patients.

The matter of dosage is distinctly affected by the personal equation of the physician. For example, one of us reached a maximum dose of 4 milliliters in 91 per cent of his plain ethyl ester groups, the other in but 53 per cent. On the other hand, the first reached this dose in but one of his forty-seven cases receiving creosoted preparations (2.1 per cent), and the other in 49 per cent of forty-five patients.

INCIDENTAL EFFECTS DURING TREATMENT

In the course of the treatment various incidental conditions have arisen, resulting directly or indirectly from the treatment, that probably have more or less bearing on the results obtained.

LOCAL EFFECTS

The local effects of intramuscular injections of chaulmoogra ethyl esters are local inflammation and, infrequently, abscess formation at or near the site of injection. Local inflammation of moderate degree is a natural and constant reaction to this drug; however, usually it causes but little discomfort, lasts but a short time, and more or less completely subsides within a week. However, because of increase of dose, increased susceptibility or, perhaps, delayed absorption, more-severe reactions frequently occur which cause greater discomfort and last longer.

The number of such more-severe local reactions occurring in each group is shown in Table 3.

TABLE 3.—*Frequency of local reactions.*

Group.	Cases.	Injections.	Reactions.	Frequency per 100.	Cases reacting.	
					Number.	*Per cent.*
I	53	1,492	64	4.3	29	54.7
II	[a] 46	1,158	68	5.9	29	63.1
III	43	1,132	75	6.6	33	76.7
IV	49	1,209	102	8.4	36	73.5

[a] The reactions occurring in three hypersusceptible cases are not included here.

In Group I, 4.3 per cent of the injections caused acute cellulitis. In the total of 1,200 injections given Group II, local reactions were caused 101 times, or 8.4 per cent. Of these 33, or 32.6 per cent of the total number, occurred in three patients. These were abnormally susceptible to the ethyl esters, for they had very frequently exhibited this phenomenon while under the previous routine treatment. Excluding these unusual cases, the reaction percentage in this group is 5.9 per cent. Why there should have been more reactions in this group than in Group I is not apparent. The highest incidence occurred in Group IV, 8.4 per cent of all injections causing inflammation; in Group III, with twice as much creosote but with camphor added, the rate was considerably less.

With the plain esters (Groups I and II), local effects are manifested by moderate pain and swelling at the site of injections with more or less induration; the general well-being of the patient is seldom if ever affected. With the creosote solutions (Groups III and IV), the effects occur not only more frequently, but also with a greater degree of severity. The inflammation is more extensive, pain is more severe, and sometimes the temperature rises to as high as 37.9° C. Thus, though the incidence rates in Groups II and III are approximately the same, the reactions in the latter group were more severe. This is the chief reason why the average doses were not as large as those of the pure ester.

Chaulmoogra ethyl ester is itself a local irritant, but combined with creosote it appears that its irritating effects are distinctly increased. Camphor, somehow or other, seems very considerably to reduce irritation. The more irritating character of the creosoted drug is not a serious drawback for the reason that the susceptibility of patients to this irritation is more marked at the beginning of treatment; it tends to disappear, gradually but entirely, in the course of treatment, so that after a time it causes induration no more frequently than does the plain drug.

Abscess formation at the site of injection is an unusual occurrence. In the series of one of us (Samson) this has been observed once in Group I, four times in two patients in Group II, twice in each, and once in Group IV. All were examined bacteriologically and found to be sterile. The other of us (Limkako) has not had any abscess in this series.

CHOKING AND COUGHING

Choking is a phenomenon not infrequently observed a few minutes after injections of chaulmoogra derivatives. It is manifested by paroxysmal cough with flushing of the face, perspiration, at times dizziness, and slight irritation of the pharyngeal walls. Just how it is produced has not been absolutely proven, though it is held to be probably due to accidental rapid introduction of the drug into the circulation. In this connection, it may be remarked that patients with choking complain of creosote taste and creosote odor of the breath. While it may not be important, the relative frequency of this incident in the different groups of our series is of interest.

In Group I it occurred three times in three patients; in Group II, four times in four patients; in Group III, twelve times in eleven patients; and in Group IV, fifteen times in eleven patients;

one of the last group had it three times. There were, therefore, seven instances with plain esters and twenty-seven with the creosoted, occurring in 0.26 and in 1.2 per cent, respectively, of the total injections, a comparative ratio of nearly 1 to 5. This relative frequency with the creosoted preparations is in spite of the fact that the average dose used has been somewhat less than that of the plain drug.

SIMPLE FEVER

An unusual effect which was observed only at the beginning of the work, in patients receiving the creosoted preparations, was a quick, temporary rise of temperature. With noncreosoted ethyl esters slight rise of temperature is often found to occur and to persist for several days after an injection; indeed, slight hyperpyrexia, of less than one degree, seems fairly common in lepers; but the patients themselves are not aware of it. From one to four hours after injection of the creosoted preparations the patients frequently complain of a sensation of heat, dizziness, and abundant perspiration. The face is flushed and the pulse slightly accelerated, the rate varying from 85 to 100 per minute, and the temperature increased. This has almost invariably been between 37.1° and 37.5° C., seldom reaching 37.8° C. This more severe reaction, as in the case of the local reaction, was seen only in the early stages of the work. After a number of injections, usually three to five, it no longer occurred.

LOCAL REACTIONS

Workers in India believe that, to get the best results, the administration of antileprosy drugs should be pushed until some degree of lepra reaction, that is, apparent activation of one or more of the lesions, with or without fever, is produced. This reaction, the mechanism of the production of which has never been explained to the satisfaction of all students of the disease, occurs universally in both the treated and the untreated lepers. It cannot be doubted that the chaulmoogra ethyl esters often serve to excite the lepra reaction. Table 4 shows the relative frequency of lepra reactions in the four groups of our series.

From Table 4 it is seen that, on the basis of total number of injections given, there was no greater incidence of lepra reactions in the creosote groups than in the plain. In fact, Group II gave the highest per cent, 3.3, while the others were almost identical, 2.5, 2.4, and 2.5. However, in the actual number of persons reacting there is a distinctly higher rate for Groups

III and IV, 49 per cent, than for I and II, 40 and 43 per cent, respectively.

TABLE 4.—*Occurrence of lepra reactions.*

Group.	Cases.	Injections.	Reactions.		Cases reacting.	
			Number.	*Per cent.*	*Number.*	*Per cent.*
I	53	1,492	36	2.5	21	40
II	49	1,200	40	3.3	21	43
III	43	1,132	27	2.4	21	49
IV	49	1,209	30	2.5	24	49

DOSE PRODUCING REACTIONS

These reactions were produced, as is to be seen in Table 5 by considerably smaller doses of the creosoted preparations than of the plain.

TABLE 5.—*Dose causing lepra reactions.*

Group.	Cases.	Doses.				Total.
		1 cc.	2 cc.	3 cc.	4 cc.	
I	53	----------	11	15	10	36
II	49	3	7	19	11	40
III	43	6	9	10	2	27
IV	49	6	14	10	----------	30

It has been our experience that the lepra reactions produced with the creosote solutions are not severe. For present purposes the classification of reactions used in this colony in 1922 will be employed here; namely, Type 1, exacerbation of old lesions with fever; Type 2, exacerbations of old lesions without fever; Type 3, eruption of fresh lesions with fever; and Type 4, fresh lesions without fever. The data on the types occurring are given in Table 6. For purposes of further comparison they are tabulated in Table 7, on the basis of duration, as follows: Very brief, less than one week; brief, one to two weeks; moderately long, two to four weeks; prolonged, more than four weeks.

TABLE 6.—*Kinds of reactions.*

Group.	Reactions.	Type 1.		Type 2.		Type 3.		Type 4.	
		Number.	*Per cent.*	*Number.*	*Per cent.*	*Number.*	*Per cent.*	*Number.*	*Per cent.*
I	36	4	11.0	5	14	5	14	22	65
II	40	3	7.5	4	10	7	18	26	65
III	27	------	--------	1	4	4	15	22	81
IV	30	------	--------	------	--------	6	20	24	80

TABLE 7.—*Duration of reactions.*

Group.	Reactions.	Very brief.		Brief.		Moderately brief.		Prolonged.	
		Number.	*Per cent.*	*Number.*	*Per cent.*	*Number.*	*Per cent.*	*Number.*	*Per cent.*
I	36	16	44	14	39	2	5.5	4	11
II	40	12	30	21	52.5	4	10	3	7.5
III	27	7	26	13	48	3	11	4	15
IV	30	2	7	12	40	9	30	7	23

As regards the type of reaction, those in Groups I and II were essentially similar, with 65 per cent of Type 4; 14 and 18 per cent of Type 3, and less of the others. In Groups III and IV, Type 4 reactions predominated still more markedly, with 81 and 80 per cent, respectively. There was but one reaction of Type 2 and none of Type 1. In other words, practically no exacerbation of old lesions was produced by the creosoted esters, and but 15 and 20 per cent, respectively, had fever with the new lesions. The reactions caused by these preparations were milder than those produced by the plain preparations.

On the other hand, the duration of reaction with the plain preparations is very distinctly less than with the creosoted. However, in view of the mildness of the reactions, it is believed that this greater duration was not harmful. General statistics of the Culion work [3] indicate that, on the whole, the reactions of longer duration are harmful; the figures for improvement given below indicate that this was not the case in the present experiment.

RESULTS OF TREATMENT

The condition of the disease at the end of six months has been compared with that at the beginning of the present treatment, based on our records and the opinions of the patients and of ourselves. The findings are given in Table 8. Here all cases are classified as apparently negative, moderately improved, slightly improved, stationary, and worse.

The total improved, stationary, and worse are plotted in fig. 2. According to these figures improvement under treatment with the creosoted preparations was distinctly greater than with the plain.

The totals (not shown in the table) were 51 per cent for the plain and 65 per cent for the creosoted. Comparing the four

[3] Personal communication from the acting chief physician; report in preparation for publication.

groups, Group I, with 43 per cent improved and 49 per cent stationary, gave by far the poorest results so far as improvement is concerned. The figures of Group II contrast interestingly, with 59 per cent improved and but 39 per cent stationary. The "worse" figure of this group, 2 per cent, is the lowest of the four.

TABLE 8.—*Progress under treatment.*

Group.	Cases.	Improved.			
		Negative.	Moderate.	Slight.	Total
I	53	2	9	12	23
II	49	0	18	11	29
III	43	1	8	16	25
IV	49	1	15	19	35

Group.	Stationary.	Worse.	Percentages.		
			Improved.	Stationary.	Worse.
I	26	4	43	49	7.5
II	19	1	59	39	2
III	12	6	58	28	14
IV	12	2	71	25	4

With the creosoted preparations, Group III gave practically the same improvement rate as Group II, but the "worse" rate, 14 per cent, was by far the highest in the series, almost twice as high as Group I, and three and a half times that of Group IV. The latter group gave the most satisfactory figures of the series; the improvement rate, 81 per cent, is higher than the next best by 12, the stationary rate is the lowest, and the worse rate, 4 per cent, is comparatively low.

These are total figures, for the groups of both of us. The individual figures, arrived at independently, correspond fairly closely.

RELATION BETWEEN AMOUNT OF CREOSOTE AND IMPROVEMENT

It has been the experience in the treatment work at Culion that, in general, the total improvement rate goes hand in hand with the amount of chaulmoogra injected. In other words, the larger the dose regularly taken the better the improvement. As regards creosote, we cannot draw any definite conclusion as to the relation between the amount administered and the improvement on the basis of the present observations. However, the

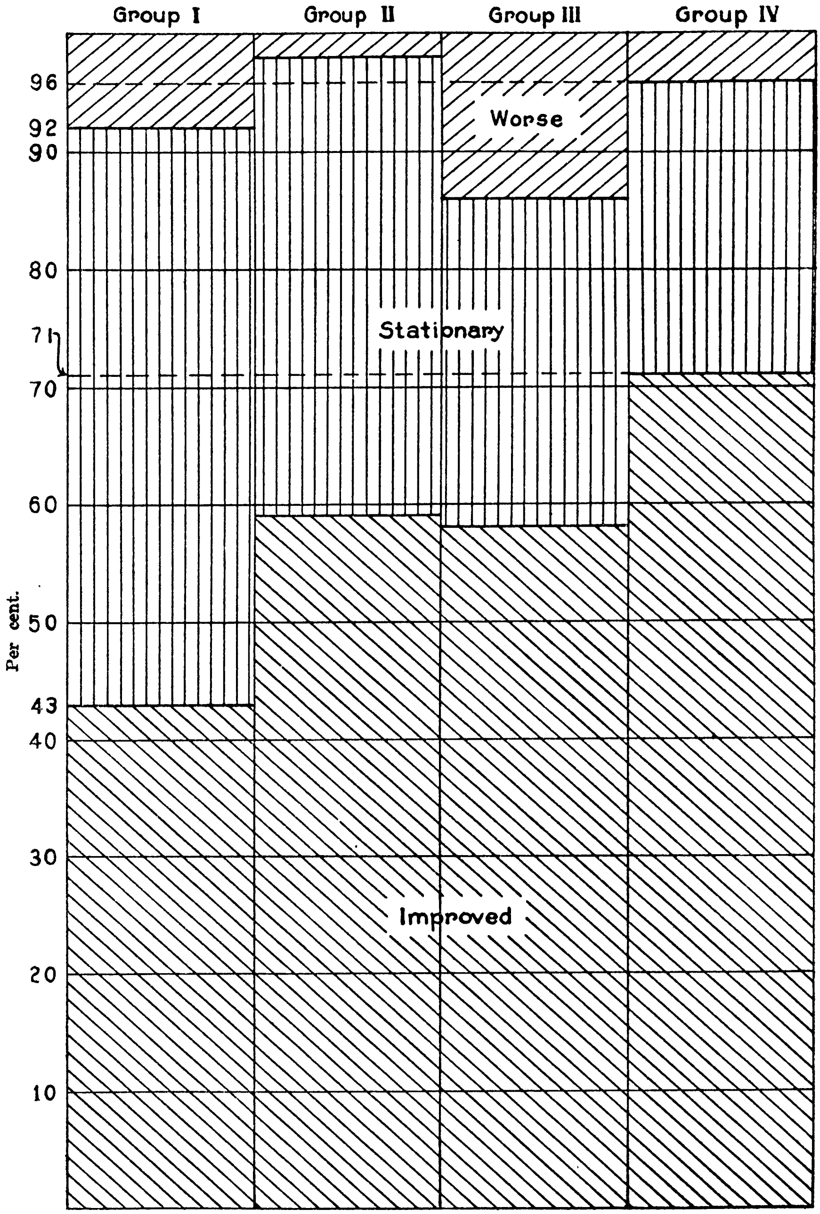

FIG. 2. Progress made by leprosy patients under treatment with creosote.

results obtained are of interest in this connection. In Group II, the maximum amount per week would be 0.6 milliliter, or about 15 grams for the whole six months, in case there were no

absences. In Group III, with the 20 per cent solution in chaulmoogra ethyl ester, 0.6 milliliter of creosote was injected in each average dose of the mixture, 3 cubic centimeters, or at most 30 grams of creosote in the six months. In Group IV with which almost a 10 per cent solution was used, practically one-half of this total amount, 15 grams, would be given.

Here are seen two interesting contrasts; namely, between the same amount of creosote given by different routes and different amounts given by the same route. In Group II, 0.6 gram per week was given by mouth. The chief result, so far as was observed, was apparent stimulation of appetite, increase of weight, and generally improved condition, with at the end better figures for improvement than in the control group. In Group IV the same amount of creosote per week was given intramuscularly. The improvement, betterment of the general condition so noticeable in the second group, was not so marked, but the first figures on improvement of the disease are the best of the series, decidedly better than for Group II, in spite of the fact that the amount of chaulmoogra given was less.

In contrast with the last group is Group III, which received by the same route 1.2 milliliters of creosote per week, together with 1.2 grams of camphor. Here the improvement rate is practically the same as in Group II, and the worse rate is by far the highest of the series. Why this preparation should give poorer results than in Group IV is not clearly apparent. While there may possibly be an element of fortuity, this is believed not determinative. It seems improbable that a 0.6 gram dose of creosote given twice a week is excessive, even by the route used, though we know of no data on the intramuscular use of this drug. It has been suggested to us that the camphor, which is not a drug that one would naturally use in such a disease in considerable dosage over a long period, may be responsible for these less favorable results.

A sidelight on the results of the treatment is given by the effects on the weight of the patients. The changes that have occurred between September, 1922, and January 15, 1923, are shown in Table 9.

Most of the control group, Group I, gained weight, but Group II showed a higher percentage, 78 against 67. Those receiving creosote by injection gave lower percentages than either Group I or Group II. Group III, with the lowest improvement and highest worse rate, reflects these results in the weight changes.

TABLE 9.—*Percentages of patients who showed change in weight.*

Group.	Cases.	Increase.			
		Marked.	Moderate.	Slight.	Total.
I	53	11.3	36.8	18.8	66.9
II	49	10.2	36.8	30.6	77.6
III	43	2.3	18.6	25.6	46.5
IV	49	4.1	36.8	18.4	59.3

Group.	No change.	Decrease.			
		Marked.	Moderate.	Slight.	Total.
I	18.8	1.9	5.7	7.5	15.1
II	10.2	2.0	4.1	6.1	12.2
III	16.3	4.6	23.3	9.3	37.2
IV	24.5	4.1	4.1	8.2	16.4

CONCLUSIONS

From the results of the observations that have been made to date, given herein, the following tentative conclusions may be drawn:

1. Creosote given in small amounts by mouth to lepers serves to stimulate the appetite, resulting in increased weight and increase in the improvement rate in cases under chaulmoogra treatment.

2. Creosote introduced into the muscle causes marked local inflammation, which in some way is to some extent prevented or reduced by camphor.

3. A greater percentage of improvement has been secured with the admixture of a moderate amount of creosote in chaulmoogra ethyl ester.

4. Large amounts of creosote, with the addition of camphor to reduce irritation, give less beneficial results, perhaps because of the injurious effect of the camphor.

5. Creosote preparations apparently cause lepra reaction in a larger number of patients than do the plain preparations, but these reactions are not severe and apparently not harmful.

ACKNOWLEDGMENT

We wish to express our appreciation to Dr. H. W. Wade, acting chief physician of the Culion Leper Colony, at whose suggestion this work was undertaken, and who has assisted us in the analysis of the results and the preparation of this report.

ILLUSTRATIONS

TEXT FIGURES

COMPARISON OF NEOTROPICAL AND PALÆOTROPICAL INSECT FAUNÆ

By C. F. BAKER

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Students of certain groups of insects, who have given attention to the faunæ of both the Neotropical and the Palæotropical Regions, have frequently found the highest interest in comparison of the general features of these faunæ as related to groups well represented in both. In certain groups of insects the Neotropics are characterized by great diversity of species in comparatively few distinct generic groups, and in certain groups a high proportion of the genera are common North American or European types. This is well exemplified in the Jassoidea, and in such genera as *Tettigonia, Diabrotica,* etc. On the other hand, in the Palæotropics, while the number of species will probably prove to be even greater (due in part to fragmentation of the territory into innumerable islands), the far greater anatomical diversity in the same groups is very conspicuous, and but few European genera may be represented. Vast numbers of strongly characterized generic groups have been formed under the latter conditions.

Papers recently published by Osborn [1] on the jassoid insects of Brazil and Bolivia clearly illustrate this. Most of the species described are referred to common North American genera and seem to be typical of them. One of these genera, *Idiocerus,* appears to be very homogeneous in structure as it is in America and Europe, whereas the same group in the Far East presents numberless distinct generic types of great diversity in structure. Comparisons of this sort yield some highly interesting data.

In connection with the above-mentioned papers, the following changes in nomenclature are suggested, in as much as they are needed for a list of the Jassoidea of the world, now about ready for publication:

Agallia sara nom. nov. for *A. major* Osb., not *A. major* Leth., 1890.
Idiocerus smithii nom. nov. for *I. fasciatus* Osb., not *I. fasciatus* Fieb., 1868.

[1] Ann. Carnegie Mus. 15[1] (March, 1923).

Scaphoideus boliviensis nom. nov. for *S. bicolor* Osb., not *S. bicolor* Ball, 1909.

Scaphoideus hasemani nom. nov. for *S. punctulatus* Osb., not *S. punctulatus* Mel., 1903.

Thamnotettix picturellus nom. nov. for *T. pictus* Osb., not *T. pictus* Leth., 1875.

Thamnotettix chapadensis nom. nov. for *T. pulchellus* Osb., not *T. pulchellus* Mel., 1907.

Objection might also be raised as to re-use of former names, even though the older combinations represent synonyms, as in the following cases:

Idiocerus rotundifrons Osb., not *I. rotundifrons* Kbm.
Platymetopius lineolatus Osb., not *P. lineolatus* Mots.
Thamnotettix sordidus Osb., not *T. sordidus* Zett.

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CHEMOTHERAPEUTIC EXPERIMENTS WITH CHAULMOOGRA AND ALLIED PREPARATIONS

By OTTO SCHÖBL [1]

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The work of Walker and Sweeney [2] aroused considerable interest among laboratory workers and was shortly afterward followed by reports along similar lines which apparently upset all prospects of working out a satisfactory chaulmoogra treatment for infectious diseases that are caused by acid-fast bacilli, particularly tuberculosis. On the other hand, most satisfactory results have been reported in the treatment of leprosy with chaulmoogra oil and its derivatives, in Hawaii; and, although these have not been duplicated in other parts of the world, the consensus of opinion with regard to the efficacy of chaulmoogra oil seems to be that the treatment brings about an improvement in the majority of leper patients, though a complete cure is not so frequent as the initial improvement of the patients leads us to hope for.

The great value of the work of Walker and Sweeney lies in their having demonstrated experimentally the possibility of working out certain fundamental problems in the chemotherapeutics of chaulmoogra treatment.

There are certain points in chaulmoogra therapy, disputed by clinical workers, which can be and have been decided by laboratory evidence. First of all, it has been demonstrated that

[1] Member, Philippine Leprosy Research Board.

[2] Walker, E. L., and Sweeney, M. A., The chemotherapeutics of the chaulmoogric acid series and other fatty acids in leprosy and tuberculosis, Journ. Inf. Dis. 1 (1920) 1.

chaulmoogra oil and some of its derivatives have a direct antagonistic action upon acid-fast bacilli, and experimental evidence allows us to deduce more definitely than does clinical observation that this action is not to be conceived as purely bactericidal, but rather in the sense of Walker's hypothesis. It can be shown by laboratory experiments that the direct antiseptic action of chaulmoogra oil is specific, in as much as chaulmoogra inhibits the growth of acid-fast bacilli in dilutions in which it has no such effect on the growth of non-acid-fast bacteria.

An attempt on the part of chemists to eliminate inert substances from chaulmoogra oil and its derivatives and thus concentrate the active principle, or to isolate the particular acid that would be most effective, yielded numerous preparations which appear to exert variable degrees of antiseptic action upon *Bacillus tuberculosis* in vitro.

It is claimed that valuable oils in chaulmoogra therapy of leprosy show a specific rotation of polarized light of about $+ 50°$. In view of this claim it seemed of interest to compare the oils obtained from various closely related species of plants with each other as to their growth-inhibiting effect and, if quantitative differences were found, to study their relation to their power of rotating the plane of polarized light and other physical and chemical properties.

It is not my intention to claim that the results of such laboratory experiments as are presented herewith can be applied directly to the treatment of leprosy, but in view of the wide use of chaulmoogra therapy study of the experimental chemotherapy of this and related drugs should be continued.

These experiments were begun shortly after the paper of Walker and Sweeney came to my attention, because of the bearing this work has on the problem of chaulmoogra treatment of leprosy. The present investigation is an attempt to answer, by experimental laboratory evidence, questions on the following and other points in the problem of chemotherapy of infectious diseases that are caused by acid-fast bacilli.

I. EXPERIMENTS IN VITRO

1. The growth-inhibiting activity of chaulmoogra oil and its derivatives.
2. Comparison of the growth-inhibiting power of chaulmoogra with that of other vegetable and animal oils, rare and common.
3. The disinfecting power of the vapors of certain vegetable oils.
4. A survey of certain organic compounds as to their growth-inhibiting activity toward acid-fast bacilli in vitro.
5. An inquiry into the mechanism and nature of the growth-inhibiting effect of chaulmoogra and other vegetable oils.

II. EXPERIMENTS IN VIVO

1. The antiseptic effect of chaulmoogra oil toward acid-fast bacilli in vivo.
2. Pathological changes produced in the organs of experimental animals, normal and tuberculous, by injections of chaulmoogra preparations.
3. The chaulmoogra therapy of experimental tuberculosis in laboratory animals with particular reference to resulting immunity.
4. The antiseptic effect upon acid-fast bacilli in vivo of such organic compounds as have been found to have a high value in vitro.

Results are given in this paper and in papers being written of my own experiments which were continued along this line as a part of the research program of the Philippine Leprosy Research Board.

1. THE GROWTH-INHIBITING ACTIVITY OF CHAULMOOGRA OIL AND ITS DERIVATIVES TOWARD BACILLUS TUBERCULOSIS IN VITRO

The technic employed in the following experiments was very simple. Measured amounts of the oils were added to test tubes containing 10 cubic centimeters of 5 per cent glycerine agar and kept in boiling water for thirty minutes. They were then vigorously shaken and cooled quickly in a slanted position. When solidified the tubes were kept in an upright position overnight to drain off the water of condensation. After planting the cotton plug was sealed with paraffin. Incubation of planted tubes followed, readings being made in two and four weeks. With each set control cultures were made, one on plain glycerine agar and one on glycerine agar containing olive oil. In the tests of sodium salts of fatty acids a solution of green soap was used as a control. The dilutions of oils were made in olive oil, those of soaps in distilled water, and the total amount of dilution added to one tube was usually 0.1 cubic centimeter, never exceeding 0.5 cubic centimeter to a test tube.

The acid-fast culture used in these experiments was an old laboratory strain of *Bacillus tuberculosis*, human type, originally obtained from the Kitasato Institute for Infectious Diseases in Tokio. The culture grew well on slightly acid beef infusion agar to which 5 per cent glycerine had been added, producing a rather moist, well emulsifiable confluent growth, which was noticeable in from eight to ten days after planting. In inoculation of the medication and the control agar tubes a small loopful of young growth was placed on the surface of the slant to be inoculated, and distributed well over the entire surface

in as thin a film as possible. A diffuse growth resulted in the inoculated agar tubes.

The results shown in the attached tables were noted at given intervals of time and were arrived at by comparing the growth in the particular agar tube with that in the control tube. Cultures showing growth scantier than that in the control tube were considered as showing inhibition of growth and so marked in the tables.

It will be noticed that my figures indicating the titer of various oils do not agree with those of Walker and Sweeney. I prefer to give as a titer the quantity of the substance added to the culture medium rather than to give the final dilution of the drug in question, for the reason that it is impossible to estimate the exact amount of drug which comes into action when solid media are used and the culture is growing on the surface only. It is reasonable to assume that a quantity smaller than the one corresponding to the amount of the final dilution comes into action at a time under such conditions. This circumstance may be considered a disadvantage; on the other hand, there is a fairly even distribution and, so to speak, fixation of those drugs which in liquid media have the tendency to gather either on the surface or at the bottom of the medication tubes, or to precipitate out of solution. Moreover, the storage effect comes into action under these circumstances. The drug stored and preserved in the solid medium is less apt to undergo such changes (hydrolysis) as take place rather rapidly in high aqueous dilutions. The drug is given off from under the surface in as concentrated a solution as its solubility in water permits and is taken up by the growing cultures in as large an amount as its solubility in water and fats allows.

Furthermore, it was the purpose of these investigations to ascertain the fundamental principles of the direct action of various drugs on acid-fast bacteria rather than to set their definite and constant antiseptic values or indices. For the same reason, as will be noticed, the final dilutions in the culture media, of the substances tested, were made at rather large and irregular quantitative intervals.

This experiment (Table 1) tends to show that chaulmoogra oil has a considerable inhibiting power over *B. tuberculosis* and that the growth-inhibiting action is specific; that is to say, the chaulmoogra inhibits the growth of *B. tuberculosis* in high dilutions while liquid paraffin and olive oil do not prevent the growth of this microbe. Non-acid-fast bacteria are not inhibited by

concentration fifty times stronger than the limit of complete specific inhibition. Cod-liver oil appears to exhibit no inhibition toward *B. tuberculosis* in a dilution 1:100, while it inhibits cholera and *Staphylococcus* completely, and *B. typhosus* partially, in a dilution of the same strength.

Comparing the growth-inhibiting effect of different oils obtained from plants related to *Taraktogenos kurzii* King with each other and with the effect of true chaulmoogra this experiment (Table 2) shows that the oil of *Hydnocarpus alcalae* C. de Candolle, a Philippine product, gives as high antiseptic value as does chaulmoogra from India, while the growth-inhibiting power of *H. wightiana* Blume is still greater; that of *H. subfalcata* Merrill is little less than that of chaulmoogra, *H. venenata* Gaertner comes next, and *Gynocardia odorata* R. Brown shows practically no effect.[3]

It is not claimed that the values given in Table 2 are absolute, but they were constant with the same samples of oils. The quantitative differences in the growth-inhibiting power of these oils suggest a comparative study of these results and those obtained in the therapy of leprosy. Furthermore, this experiment brings out a point which seems to be of great interest. It can be seen from Table 2 that all of the oils in question, with the exception of *Gynocardia odorata*, show more or less a growth-inhibiting effect. Some years ago Brill[4] conducted a chemical study of chaulmoogra and related Philippine oils and came to the conclusion that all of them, with the exception of *G. odorata*, contain in various degrees the acids peculiar to chaulmoogra. On the other hand, Brill found other substances such as glucosides to be present in all of the oils, including *G. odorata*. From these findings he concluded that oils other than true chaulmoogra, with the exception of *G. odorata*, should have a similar therapeutic effect if the curative value of chaulmoogra is due to the presence of the peculiar acids. On the other hand, if the therapeutic effect of chaulmoogra is due to substances other than the acids, *G. odorata* should be just as valuable a drug as chaulmoogra. My bacteriologic observations are in agreement with the chemical findings of Brill, whose findings confirm those made previously by Power.

It is further evident from this table that the growth-inhibiting activity of these oils is specific.

[3] The hydnocarpus oils were kindly furnished by Dr. G. A. Perkins. See the paper by G. A. Perkins and A. O. Cruz, postea, page 543.

[4] Philip. Journ. Sci. § A 11 (1916) 75.

In order to make Table 3 intelligible, the method of preparation of the various soaps used in these experiments is taken from a paper by G. A. Perkins,[5] whose preparations I used.

Sodium gynocardate A. This is the derivative of chaulmoogra oil used for subcutaneous and intravenous injection since 1917 by Sir Leonard Rogers.

Sodium gynocardate S. This preparation was made in the same manner as sodium gynocardate A, except that the total fatty acids instead of the crystallized acids were employed.

Sodium gynocardate D. Differs from sodium gynocardate S only in that the fatty acids have been purified by distillation in vacuum.

The sodium morrhuate was prepared by Rogers's method. This consists in making the sodium soap of cod-liver oil and extracting with ether to remove irritating substances.

The results of experiments tabulated in Table 3 confirm the findings of Walker and Sweeney in their Table VII. It shows that sodium gynocardate S, a soap made of the total fatty acids of chaulmoogra oil, gives the highest antiseptic value; sodium gynocardate D (distillate) is next strongest, and sodium gynocardate A (Rogers) is not so strong as the other two soaps mentioned. Due probably to different technic, the differences in the effect of the various preparations are not so pronounced as in the experiments of Walker and Sweeney, but they are distinct.

The soaps made from isolated acids of chaulmoogra oil, [5] that is, sodium chaulmoograte and sodium hydnocarpate, show lower value than do the gynocardates, the hydnocarpate value being at least twenty times that of the chaulmoograte.

CONCLUSIONS

1. Chaulmoogra oil and its derivatives exert a pronounced growth-inhibiting action on *Bacillus tuberculosis* in vitro.

2. This inhibition is specific; that is to say, it is noticeable in dilutions of the oil in which no inhibition of non-acid-fast bacilli can be discerned.

3. Oils obtained from plants related to *Taraktogenos kurzii* have a property similar to that of chaulmoogra oil with regard to *Bacillus tuberculosis*. *Hydnocarpus wightiana*, *H. alcalae*, *H. subfalcata*, and *H. venenata*, all containing the optically active acids, show antiseptic power in vitro, the strength of the various

[5] For details see Philip. Journ. Sci. 21 (1922) 1–15.

oils decreasing in the order mentioned. Oil derived from *Gynocardia odorata,* a plant systematically closely related to *Taraktogenos kurzii,* proved to be inactive in our experiments. It lacks the optically active fatty acids.

4. The growth-inhibiting strength of the sodium salts of chaulmoogra oil acids appears to vary, in as much as the soap made from the total fatty acids inhibits the growth of *Bacillus tuberculosis* to a higher degree than does that made of a fraction of the acids.

5. A sodium salt prepared from isolated hydnocarpic acid approaches closely in strength the soap of total fatty acids, while the sodium salt of chaulmoogric acid is far below the soap of hydnocarpic acids as far as the growth-inhibiting effect is concerned.

The following abbreviations are used in Tables 1, 2, and 3:

$\genfrac{}{}{0pt}{}{-}{-}$, no growth in two and four weeks.

$\genfrac{}{}{0pt}{}{-}{+\ \text{inh}}$, no growth in two weeks; growth in four weeks less than controls.

$\genfrac{}{}{0pt}{}{+\ \text{inh}}{+\ \text{inh}}$, growth in two and four weeks scantier than controls.

+, growth as good as controls.

$\genfrac{}{}{0pt}{}{+}{+}$, growth in two and four weeks as good as controls.

0, not tested.

—, no growth.

+ inh, inhibition growth scantier than controls.

$\genfrac{}{}{0pt}{}{+\ \text{inh}}{+}$, growth scantier than controls in two weeks; as good as controls in four weeks.

$\genfrac{}{}{0pt}{}{-}{+\ \text{m inh}}$, growth poorer than in sodium gynocardate A culture tube.

$\genfrac{}{}{0pt}{}{-}{+\ \text{v. m inh}}$, growth poorer than in so$^{\text{di}}$um gynocardate D culture tube.

TABLE 1.—*Growth-inhibiting effect of chaulmoogra oil as compared with inert oils.*

[Symbols are explained in the last paragraph of text.]

Name.	Cubic centimeters of oil added to one slant of agar.								
	Bacillus tuberculosis.						Typhoid.	Cholera.	Staphylo-coccus.
	0.1	0.05	0.01	0.005	0.001	0.0005	0.1	0.1	0.1
Chaulmoogra oil, India	—	—	—	—	—	+ inh	+	+	+
	—	—	—	—	+ inh	+ inh			
Chaulmoogra oil, Japan	—	—	—	—	+	+	+	+	+
	—	—	—	+ inh	+	+			
Paraffin liquid	+	+	+	0	0	0	+	+	+
	+	+	+						
Olive oil	+	+	+	0	0	0	+	+	+
	+	+	+						
Cod-liver oil	+	+	+	+	+	+	+ inh	—	—
	+	+	+	+	+	+			

TABLE 2.—*Comparison of growth-inhibiting effect of oils obtained from plants closely related to Taraktogenos kurzii.*

[Symbols are explained in the last paragraph of text.]

Name.	Cubic centimeters of oil added to one slant of agar.								
	Bacillus tuberculosis.						Typhoid.	Cholera.	Staphylococcus.
	0.1	0.05	0.01	0.005	0.001	0.0005	0.1	0.1	0.1
Hydnocarpus wightiana	—	—	—	—	—	+ inh	+	+	+
	—	—	—	—	—	+			
Hydnocarpus venenata; Brill[a]	—	—	—	—	+	+	+	+	+
	—	—	+ inh	+ inh	+	+			
Hydnocarpus subfalcata; Perkins	—	—	—	—	+	+	+	+	+
	—	—	+ inh	+ inh	+	+			
Hydnocarpus alcalae	—	—	—	—	+	+	+	+	+
	—	—	—	—	+ inh	+			
Gynocardia odorata	+	+	+	+	+	+	+	+	+
	+	+	+	+	+	+			

[a] Sample several years old.

TABLE 3.—*Comparison of growth-inhibiting effect of chaulmoogra soaps prepared from various fractions and isolated acids.*

[Symbols are explained in the last paragraph of text.]

Name.	Concentration.	Cubic centimeters of soap solution added to one slant of agar *B. tuberculosis*.							
		0.1	0.05	0.01	0.005	0.001	0.0005	0.0001	0.00005
	Per cent.								
Sodium gynocardate A No. 104	3	−	−	−	−	+	+	0	0
		−	−	−	+ inh	+	+		
Sodium gynocardate D No. 104	3	−	−	−	−	+	+	0	0
		−	−	−	+ m inh	+	+		
Sodium gynocardate S No. 104	3	−	−	−	−	+	+	0	0
		−	−	−	+ v. m inh	+	+		
Sodium hydnocarpate C. P.	3	−	−	−	+ inh	+	+	0	0
		−	−	+	+	+	+		
Sodium chaulmoograte C. P.	3	+ inh	+ inh	+ inh	+	+	+	0	0
		+	+	+	+	+	+		
Sodium morrhuate	3	−	+	+	+	+	+	0	0
		+	+	+	+	+	+		
Green soap	1	+	+	+	+	+	+	0	0
		+	+	+	+	+	+		

A COMPARATIVE ANALYTICAL STUDY OF VARIOUS OILS IN THE CHAULMOOGRA GROUP [1]

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ONE PLATE

Although there is no longer room for doubt that chaulmoogra oil and certain hydnocarpus oils contain substances which are valuable in the treatment of leprosy, the relative value of the various oils and of the substances which they contain, still remains unknown. The discovery of chaulmoogric and hydnocarpic acids by Power,[2] the successful clinical use of pure esters of these acids by Hollmann, Dean, and McDonald,[3] and the bacteriological studies of Walker and Sweeney,[4] have given a scientific basis to chaulmoogra therapy in a qualitative and preliminary way; but much remains to be done before the bacteriologist and clinician can be given a satisfactory chemical description of the chaulmoogra group of oils.

The information contained in Table 1 summarizes practically all of the analytical results on the chaulmoogra group which have hitherto been published by various investigators, although much more work has been done than one would infer from a glance at this table. Compared to many tables of oil "constants" this table may appear complete, but an examination of the literature represented discloses three deficiencies which are very

[1] Published by permission of the Director of Health and the Philippine Leprosy Research Board. Submitted for publication June 6, 1923.

[2] Power, F. B., and Gornall, F. H., Journ. Chem. Soc. **85** (1904) 838; Power, F. B., and Barrowcliff, M., Journ. Chem. Soc. **87** (1905) 884.

[3] Hollmann, H. T., and Dean, A. L., Journ. Cutan. Dis. **37** (1919) 375; McDonald, J. T., Journ. Am. Med. Assoc. **75** (1920) 1485.

[4] Walker, E. L., and Sweeney, M. A., Journ. Infect. Dis. **26** (1920) 238.

important from the therapeutic standpoint, namely: The chemical work has been confined to less than half of the oils which, from botanical and other reasons, may be confidently placed in the chaulmoogra group. The various constituents have not been determined quantitatively. Unknown constituents are present in probably all of the oils and may form a large part of certain oils.

One of the aims of the chemical laboratory at Culion Leper Colony is to take a part in remedying these deficiencies in our knowledge of chaulmoogra, and it is hoped that the present study will be found a step in that direction. Our field was necessarily limited to oils which we were able to obtain and the following objectives were held in mind:

1. Establishment of criteria for the recognition of each oil if possible, and for the detection of adulteration.
2. Sufficient separation of each oil into its constituents as would enable its evaluation as a potential source of hydnocarpic, chaulmoogric, or some unknown fatty acid in case any of these should be found by clinicians particularly valuable therapeutically.
3. Determination of economically important considerations, such as yield of oil, keeping qualities of seeds, etc.

The study has included work on a few commercial oils, but has been chiefly devoted to samples obtained in the laboratory from seeds of known species. Ten species were included: *Taraktogenos kurzii*, seven species of *Hydnocarpus*, *Pangium edule*, and *Gynocardia odorata*. *Taraktogenos kurzii* is the true chaulmoogra, but the genus *Hydnocarpus* is very closely allied both botanically and chemically to the genus *Taraktogenos*. *Hydnocarpus* oils are, therefore, included in the chaulmoogra group and some of them may be as effective as or possibly more effective against leprosy than chaulmoogra oil. Three of the *Hydnocarpus* species studied are found only in the Philippines, two are Indian species, one is from Borneo, and one from Indo-China. *Gynocardia odorata* and probably *Pangium edule* cannot be classed in the chaulmoogra group, but were included in the study to clear up certain errors and discrepancies existing in the literature concerning their relation to this group. Only three of these species are additional to the list in Table 1, but we hope to be able to obtain other species and extend the work.

DISCUSSION OF SEEDS USED [5]

GYNOCARDIA ODORATA R. BROWN

This seed is found in the forests of Assam, where it is even now confused with *Taraktogenos kurzii.* Although Power and Barrowcliff found the *Gynocardia* oil to be entirely different from *Taraktogenos* oil (see Table 1), this oil was included in our study because of the contradictory report of Brill and Williams [6] on a sample of "*Gynocardia odorata*" purchased through the Department of Agriculture, Assam. We have not only confirmed Power's results, but have, like Brill and Williams, found it difficult to obtain genuine *Gynocardia* seeds from Assam. This is surprising in view of the easy distinction pointed out by Muir.[7] The radical of the *Gynocardia* seed is lateral, while that of the *Taraktogenos* and *Hydnocarpus* is terminal.

The *Gynocardia* seeds used in this study were purchased from a Calcutta firm.

HYDNOCARPUS ALCALAE C. DE CANDOLLE

This is the largest *Hydnocarpus* seed known to us and is the only Philippine species which we have succeeded in obtaining in commercial quantities. Our supply has been obtained from the Provincial Treasurer of Albay (samples *A* and *C*), and from ex-Governor Timoteo Alcalá of that province (sample *B*). The local names are *dudóa* and *dudu-dudu.* The fruit is about 20 centimeters long and 10 to 12 centimeters in diameter. The seeds are about 3 centimeters long. January and February seem to be the best months for collecting this fruit.

HYDNOCARPUS ANTHELMINTHICA PIERRE

This well-known seed, *lukrabao* (*lukrabo*), is found extensively in Indo-China. Our samples were purchased from a Bangkok firm.

[5] Botanical and economic data on *Gynocardia odorata, Hydnocarpus anthelminthica, H. castanea* (of which we have no specimens for this study), and *Taraktogenos kurzii* have been reported by J. F. Rock in The Chaulmoogra Tree and Related Species, Bull. U. S. Dept. Agr. **1057** (1922).

[6] Brill, H. C., and Williams, R. R., Philip. Journ. Sci. § A **12** (1917) 211.

[7] Muir, E., Handbook on Leprosy, Orissa Mission Press, Cuttack, India (1921) 39.

TABLE 1.—*Physical and chemical data already available on chaulmoogra and related oils.*

Species.	Yield of oil from seeds.	Specific gravity.	Refractive index.	Melting point.	Specific rotatory power.	Iodine value.	Saponification value.	Acid value.
	P. ct.			°*C*			*mg. KOH.*	*mg. KOH.*
Gynocardia odorata (pressed oil)[a]	19.5	0.925 at 25°	----------	20	Nil.	152.8	197.0	4.9
Hydnocarpus alcalae[b]	40.8	0.9502 at 30°	1.4770	32	+49.60	93.1	188.9	21.8
Hydnocarpus alpina[c]	----------	0.898 at 100°	1.4709 at 40°	22–26	+49.5	84	207	0.35
Hydnocarpus anthelminthica (pressed oil)[d,e]	16.3	0.953 at 25°	1.473	24–25	+52.5	86.4	212.0	7.5
Hydnocarpus venenata (pressed oil)[f]	23.3	0.9475 at 30°	1.4770 at 30°	19–20	+52.03	99.1	200.3	24.7
Hydnocarpus wightiana (pressed oil)[d,g]	32.4	0.958 at 25°	----------	22–23	+57.7	101.3	207.0	3.8
Oncoba echinata (extracted oil)[h]	47	0.898 100/15.5	----------	35–45	+48.8	99.7	192.4	4.5
Pangium edule[b]	6.1	0.9049 (0.9092)	1.4665	2	+ 4.28 (20.65)	113.1	190.3	2.9
Taraktogenos kurzii (pressed oil)[i,e]	30.9	0.951 at 25°	1.476	22–23	+52.0	103.2	213.0	23.9

Species.	Chaulmoogric acid.	Hydnocarpic acid.	Other constituents.	Fatty acids, melting point.	Fatty acids, specific rotatory power.
				°*C*	
Gynocardia odorata (pressed oil)[a]	None	None	Gynocardin, linolic, palmitic, linolenic oleic.	----------	None.
Hydnocarpus alcalae[b]	Approximately 90 per cent	None ?	Palmitic, oleic	59	+53.65
Hydnocarpus alpina[c]	Indicated	Indicated	----------	----------	
Hydnocarpus anthelminthica (pressed oil)[b,e]	Present	Present	Glucoside, oleic, palmitic	42–43	+53.6

Hydnocarpus venenata (pressed oil)[f]	do	do	Glucoside	43	+60.96
Hydnocarpus wightiana (pressed oil)[d,g]	do	do	Unknown unsaturated acid	41–44	+60.4
Oncoba echinata (extracted oil)[h]	84.5 per cent		No palmitic, liquid acids 12 per cent		+52.5
Pangium edule[b]	Indicated	Indicated	Unsap. 1.5 per cent, gynocardin, palmitic	18	+ 3.49 (4.72)
Taraktogenos kurzii (pressed oil)[i,e]	Present	Present	Glucoside, palmitic acid	44–45	+52.6

[a] Power, F. B., and Barrowcliff, M., Journ. Chem. Soc. **87** (1905) 896. The extracted oil was very similar except that the yield was 27.2 per cent.

[b] Brill, H. C., Philip. Journ. Sci. § A **12** (1917) 37.

[c] Wolf, H. H., de, and Koldewijn, H. B, Pharm. Weekblad **49** (1912) 1049, as abstracted in Chem. Centralblatt **84** (1913) 31.

[d] Hollmann, H. T., and Dean, A. L., Journ. Cutan. Dis. **37** (1919) 375; McDonald, J. T., Journ. Am. Med. Assoc. **75** (1920) 1485.

[e] Data on the extracted oil are very similar.

[f] Brill, H. C., Philip. Journ. Sci. § A **11** (1916) 75.

[g] Data on the extracted oil are very similar, except the yield, 41.2 per cent.

[h] Goulding, E., and Akers, N. C., Proc. Chem. Soc. **29** (1913) 197.

[i] Power, F. B., and Gornall, F. H., Journ. Chem. Soc. **85** (1904) 838; Power, F. B., and Barrowcliff, M., Journ. Chem. Soc. **87** (1905) 884.

HYDNOCARPUS HUTCHINSONII MERRILL

The following description of *Hydnocarpus hutchinsonii* is quoted from Bureau of Science press bulletin No. 105, January 27, 1922:

Found in the eastern part of Mindanao, on Basilan Island, in the Sulu Archipelago, and in British North Borneo. The tree grows to a height of 25 meters but is usually not over 15 meters in height. Most of the trees have a diameter of 10 to 15 cm, one meter from the ground, but the larger specimens attain a diameter of 35 cm. The bark is rather smooth, often stippled. It is found in the primary forest, but the largest specimens are found in the bog or cut-over forest. It is found from sea level to at least 600 meters altitude.

Leaves.—The leaves are oblong, smooth edged, 15 to 30 cm long, 5 to 12 cm wide, the base distinctly inequilateral, usually rounded or obtuse on the broader side, and often acute on the narrower side, the apex rather abruptly and distinctly pointed. The upper surface is dark green, shining, smooth, the lower surface brownish, distinctly showing reticulated veins. The lateral veins 12 to 14 on each side of the midrib, prominent, curved, anastomosing close to the margin. Petioles usually about 1 cm long.

Flowers.—Small, yellow flowers about 1 cm long.

Fruits.—The tree fruits in July or August although a few fruits are found at other times of the year. The fruit is almost spherical, from 7 to 10 cm in diameter, with a short stocky stem. The shell (pericarp) is rather thin and brittle when dry, with a smooth surface. The fruit contains from 20 to 45 seeds in a small amount of pulp. The fruit is a light brownish green on the tree, turning to a brown when dried. The appearance roughly resembles that of an orange.

Seeds.—The seeds are packed tightly in the fruit and hence have a rounded polygonal shape not over 2.5 cm long. When dried, part of the seed is smooth with slight ridges, and part covered with tiny warts. The shell of the seed is thin, brittle, and brown when ripe. The kernel is solid, white, oily, odorless, and rather tasteless.

Local names.—The tree is known by the people of various districts as follows: Basilan—*mansaloka, mangasalokag;* Zamboanga Peninsula—*kamupang, dinagas, tioto, sugalingayan;* Lanao—*bagarbas, kalumpang;* Jolo—*kaumpang, kamupang.*

Collection of fruit.—The fruit falls about July or August and should be collected at that time, and the seeds removed and dried immediately to prevent molding.

Dr. H. I. Cole, of the Bureau of Science, in a recent extensive survey found a large supply of these seeds in Mindanao forests, but the difficulty in collecting them and the relatively high price of Moro labor have prevented us from obtaining a regular supply. The samples used in this study were collected at Basilan, Zamboanga, by Doctor Cole with the coöperation of the Bureau of Forestry.

HYDNOCARPUS SUBFALCATA MERRILL

Quoting from the same bulletin as before:

This species is found in Zambales, Pangasinan, and Cagayan, Luzon; Sibuyan, Samar, and Mindanao (Surigao). It bears a green fruit 1 to 4 cm in diameter containing from 2 to 8 small seeds. Its local names are *mala usa*, *binting dalaga*, *amitan* (Ibn.), *apanang* (C. Bis.), *dalinias* (Sbl.), *damol* (S. L. Bis.), *lagtang* (P. Bis.), *n̄geret* (Tag.), pai (Pang.), *putian* (Sbl.).

A small supply of *H. subfalcata* seeds has been obtained from the Provincial Treasurer of Zambales. The fruit ripens in May.

HYDNOCARPUS VENENATA GAERTNER

The seeds of this species are similar to those of *Hydnocarpus wightiana* (see the following species) but are smaller, and have seven veins in the cotyledon instead of five. Our samples were obtained from Ceylon, through the Superintendent of the Peradeniya Gardens. This species is said to be found also in East and West Deccan, and in Burma.

HYDNOCARPUS WIGHTIANA BLUME

This species appears to be available in larger quantities than any of the other species of the chaulmoogra group. The seed is about 2 centimeters long with longitudinal grooves, and a knob at the end. It is found in southwestern India and shipped in commercial quantities from Ernakulam. The Ernakulam Trading Co. also presses out and exports the oil.

HYDNOCARPUS WOODII MERRILL

Our sample of this species was collected by Mr. A. D. E. Elmer, in British North Borneo, near Sandakan. The seed is similar to that of *Hydnocarpus hutchinsonii.*

PANGIUM EDULE REINWARDT

This seed has been examined by Brill (see Table 1 and references), who concluded that it contained chaulmoogric or hydnocarpic acids. Our results, as will be seen, are not in accord with this conclusion. The species is widely distributed in the Philippines and neighboring islands. Our samples were obtained from Zamboanga.

TARAKTOGENOS KURZII KING

This seed, the official chaulmoogra, is quite different from *Hydnocarpus wightiana* in external appearance, being smooth

and somewhat larger. The interior structure of the two seeds is very similar; but, judging from our experience, *Taraktogenos kurzii* becomes rancid rapidly, while *Hydnocarpus wightiana* keeps well for years. Most of our supply of seed was obtained through a Rangoon firm, probably from Chindwin Valley. Other sources are Assam and Bengal. On account of the poor keeping qualities of the seed, shipments from Chittagong (the most important chaulmoogra oil center) are made chiefly in the form of oil.

EXTRACTION OF THE OILS

The data on yield of oil, amount of shell, etc., of the ten species are collected in Table 2, the items being as follows:

Sample.—The samples are described in the previous section. Usually a 2,000-gram sample was taken, which gave sufficient oil for the distillation test. A larger sample of *Pangium edule* was necessary.

Estimated age.—The age alone does not determine the condition of the sample. Almost all of the samples were sundried immediately after collection, but in many cases this was not done with sufficient thoroughness. In the dry conditon all of the seeds seem to be quite stable.

Approximate weight.—Usually twenty representative seeds were chosen for this determination. Considerable variation in size will be noted. The large seeds of the chaulmoogra group are *Hydnocarpus alcalae* and *H. woodii.* Of these the former has much the larger fruit.

Shells of first- and second-grade seeds.—The basis of grading is explained in the next paragraph. The weights of shells in each grade are given because they show approximately the relative numbers of first- and second-grade seeds in the sample.

First- and second-grade kernels.—Kernels which showed no gross destruction by mold were considered first grade. Probably all of the kernels would have been of this grade if they had been properly dried as soon as they became ripe. Such kernels showed in general only slight signs of aging, but *Taraktogenos kurzii* kernels show a marked tendency to darken and acquire a rancid odor, even though quite dry. *Hydnocarpus wightiana* on the other hand, retains a fresh odor, taste, and appearance for many months if kept fairly dry.

The second-grade kernels were often almost totally destroyed by mold, so that low yields of oil were obtained in cases where a large proportion of the seeds had molded.

Moisture.—The figures for moisture were obtained incidentally while drying the ground kernels for extraction.

Solvent.—The dry ground kernels were extracted in an apparatus of the Soxhlet type. Because the work was done in different laboratories the solvent was varied to suit the apparatus used.

First- and second-grade oil.—The oil from the first-grade kernels, rather than the total oil, was chosen for the analytical work because of the extensive decomposition which had occurred in the second-grade oil. The free fatty acid figures in Table 3 show the comparatively well-preserved character of the first-grade oil.

The low oil yield occasioned by imperfect drying is well shown in the figures for *Hydnocarpus alcalae, B.*

CHARACTERISTICS OF THE OILS

General.—Table 3 shows the results of some of the usual physical and chemical tests on the oils studied. All of the determinations made have value for certain purposes, but the optical rotation is obviously the outstanding characteristic of the chaulmoogra group. The iodine number and the freezing point of the fatty acids afford in certain cases means of distinguishing one member of the group from others, and the acidity is an index of the degree of preservation. Conclusions as to the variations in each characteristic as well as descriptions of the methods used follow under the appropriate headings.

All of the oils were liquid at room temperature (30° C.), but one rancid commercial chaulmoogra oil (*Taraktogenos kurzii, G*) had a large proportion of solid deposit. The color of the pressed oils varied, according to the care used in manufacture, from a yellow similar to that of good olive oil (*Taraktogenos kurzii, G*) to a reddish brown (*Taraktogenos kurzii, G*). The first-grade extracted oils had a color similar to the darker pressed oils and the second-grade extracted oils were very dark.

Samples.—The samples designated as first-grade and second-grade were the extracted oils obtained as shown in Table 1.

Hydnocarpus subfalcata, B, was a cold pressed oil obtained from first-grade *Hydnocarpus subfalcata* kernels.

Hydnocarpus wightiana, B and *C,* were commercial pressed oils obtained from Calcutta dealers.

Taraktogenos kurzii, B to *N,* were commercial oils sold as chaulmoogra by various dealers. Of these, *N* is obviously adulterated, and *C* is suspiciously like *Hydnocarpus wightiana* in

TABLE 2.—*Extraction of the oils.*

[All percentages are based on the total original sample.]

Sample.	Estimated age.	Approximate weight of one seed.	Shells of first-grade seeds.	Shells of second-grade seeds.	First-grade kernels.	Second-grade kernels.	Moisture.	Solvent.	First-grade oil.	Second-grade oil.	Total oil.
	Months.	*Grams.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*		*Per cent.*	*Per cent.*	*Per cent.*
Gynocardia odorata	10	1.1	26.5	2.0	68.0	2.0	----------	Benzene	26.0	----------	26.0
Hydnocarpus alcalae:											
A	6	2.2	----------	----------	32.6	32.6	3.8	Toluene	22.7	16.9	39.6
B	2	4.2	18.6	9.5	52.6	7.8	17.8	do	18.0	2.6	20.6
C	12	3.3	13.5	22.0	32.0	31.8	2.8	Benzene	18.9	19.5	38.4
Hydnocarpus anthelminthica	11	1.4	66.0	None.	30.2	None.	1.7	do	12.2	None.	12.2
Hydnocarpus hutchinsonii	4	1.6	18.6	22.2	45.7	7.6	4.5	Toluene	17.8	5.1	22.9
Hydnocarpus subfalcata	8	0.7	21.5	13.3	48.6	15.0	2.0	Benzene	27.5	8.4	35.9
Hydnocarpus venenata	5	0.3	18.5	32.0	38.5	11.0	2.3	do	22.6	7.0	29.6
Hydnocarpus wightiana	14	1.2	33.5	2.0	60.5	4.0	2.4	do	38.3	2.9	41.2
Hydnocarpus woodii:											
A	12	----------	----------	----------	36.5	4.4	----------	Ether	8.8	2.2	11.0
B	12	4.2	56.0	None.	44.0	None.	----------	do	20.6	None.	20.6
Pangium edule:											
A	2	14.4	30.4	20.3	30.4	14.7	13.6	Toluene	5.7	2.4	8.1
B	2	11.5	21.8	25.0	23.6	19.0	3.6	Benzene	7.3	8.1	15.4
Taraktogenos kurzii	8	1.9	27.2	15.5	45.9	10.4	2.0	do	23.5	5.3	28.8

rotation and freezing point of fatty acids. Sample *G* is typical of the commonly found rancid commercial chaulmoogra oil which is dark brown when melted but has a large amount of light semisolid deposit even at 30° C. Many physicians and patients accustomed to this product, obtained from partly rotten seeds, look with suspicion on the more carefully prepared oils. Samples *H, I,* and *L* were obtained from P. K. Sen, Chittagong, India. We were informed from reliable sources at the time that only selected *Taraktogenos kurzii* seeds were used by this manufacturer, and that the oil was cold pressed. These oils were of much better quality than the crude oils above mentioned, having less color, acidity, and odor and practically no sediment at 30° C. The most carefully manufactured oils which we were able to obtain were *D, E,* and *J,* from Shiongi & Co., Osaka, Japan. These samples were very light in color, clear, and almost odorless, but it is difficult to decide from the data whether they are *Taraktogenos kurzii* or *Hydnocarpus wightiana.*

Specific gravity.—The determination of specific gravity was made with a hydrometer at 30° C. Different samples of the oil from the same species show expected variations on account of varied acidity, difference in treatment, etc. The oils of the chaulmoogra group all show a high specific gravity (0.943 to 0.956), matched by only a few other oils.

Due to its variation in different samples of the same oil, the specific gravity is of no value in determining the species of an unknown oil, but a specific gravity below 0.940 in an alleged chaulmoogra or hydnocarpus oil would indicate adulteration.

Refractive index.—An Abbe refractometer was used, either at 30° C. or within one or two degrees of this temperature. In the latter case a correction of 0.00038 per degree was applied.

The chaulmoogra group shows a high refractive index, but not sufficiently high to be distinctive, and there seems to be no significant variation within the group.

Freezing point.—This simple though rather inexact determination was made to obtain a relative idea of the tendency to solidity exhibited by the various oils. The sample was cooled in a test tube and the temperature at which it became semisolid was noted. (See also freezing point of fatty acids.)

Rotation.—The optical rotation was determined in a quartz wedge saccharimeter, using white light filtered through dichromate. Usually the sample was placed in a 4-centimeter tube. All results are expressed in angular degrees per decimeter, as is customary for optically active liquids. To compare these

figures with the specific rotatory power figures given in Table 1, the latter are to be multiplied by the specific gravity.

Optical rotation is unquestionably the most characteristic simple property of the chaulmoogra group. Many other oils show some rotation, but none outside of the chaulmoogra group are known with a rotation as high as 45° to 50°. Of the oils studied *Gynocardia odorata,* with no rotation, is definitely outside of the chaulmoogric group, but *Pangium edule* shows a rotation of 2.8° to 16.9°. The composition of this oil is discussed on another page. The other oils, definitely in the chaulmoogra group, have the rather narrow range of 43.5° to 51.6°. *Taraktogenos kurzii,* counting only the authenticated samples, has a range of 43.5° to 46.3°. Our samples of *Hydnocarpus anthelminthica, H. hutchinsonii, H. venenata,* and *H. woodii* also fall within these limits, but *H. alcalae, H. subfalcata,* and *H. wightiana* give definitely higher values. The inference is that the last-mentioned three oils contain more chaulmoogric, hydnocarpic, or similar acids than true chaulmoogra and are, therefore, slightly superior to it for medicinal use. In our present state of knowledge, both chemical and clinical, these cannot be considered as established facts, but only as suggestive indications.

The difference in rotation between the two samples of *Hydnocarpus subfalcata* is possibly due to the fact that sample *A* is extracted, while sample *B* is pressed.

Iodine number.—The Hanus method was used, one hour being found a convenient time to insure complete absorption. The figure given in each case is the average of two closely agreeing determinations.

The iodine number is of some value in distinguishing between the different oils of the chaulmoogra group, as may be seen in Table 3. The authentic chaulmoogra samples show an iodine number very close to 100, and *Hydnocarpus wightiana* is the only other in the chaulmoogra group as high as this. *Hydnocarpus alcalae* is not much different, but the rest seem to be definitely lower.

A high iodine number indicates the absence of saturated fatty acids and the presence of acids less saturated than those in the chaulmoogric series; the former are probably relatively inactive, but it remains for clinicians to discover whether the latter are beneficial or harmful. If, as is indicated by Power's

work,[8] some of the strongly unsaturated acids contain the chaulmoogric grouping as well as a double bond, these acids would be expected to be very active, but not necessarily in a beneficial way.

Saponification number.—This was determined in the usual manner, and is expressed in milligrams of potassium hydroxide per gram of oil. It is about 200 in all of the oils studied.

Acidity.—As none of the seeds were strictly fresh a slight rancidity and corresponding acidity were to be expected. The *Taraktogenos kurzii, A* (first grade) oil showed surprisingly little acidity, although the seeds were more rancid than those of *Hydnocarpus wightiana.* Commercial chaulmoogra oil is usually very rancid, and only a small proportion of oil as good in this respect as *D, E,* and *J* is to be found on the market.

Freezing point of the fatty acids.—This was determined in the same manner as the freezing point of the oil, and is a simplified titer test. Only the insoluble acids were used, the soluble acids being negligible. The freezing point was quite sharp in most cases and is, therefore, more characteristic than the freezing point of the oil.

The authentic *Taraktogenos kurzii* samples gave, in this test, the low figures of 22° to 29° for pressed oils and 32° for the extracted oil. This distinguishes them, though not very sharply, from all the other authentic chaulmoogra-group samples, which gave 34° to 39° for the pressed oils and 36° to 55° for the extracted. *Hydnocarpus alcalae* stands entirely alone, giving a value (55°) 8° higher than that of the nearest competitor, *H. venenata* (47°). The remaining five oils range only between 34° and 43°.

The connection between this determination and composition can be shown better later in the paper, when the freezing points of various fractions are discussed.

Specific rotatory power of the fatty acids.—This value was found by "polarizing" a xylene solution of the fatty acids, using 2 grams or 5 grams in 50 mils. The readings were converted to angular degrees, and divided, as is usual for substances in solution, by the concentration and the length of the tube in decimeters.

Due to the difficulties in using high concentrations, especially because of the color, these values were not as accurately deter-

[8] Power, F. B., and Barrowcliff, M., Journ. Chem. Soc. 87 (1905) 891.

mined as were the rotations of the oils themselves, but they serve to show that the variation of optical rotation in the different oils is really due to differences in the composition of the fatty acid fraction and not to differences in the manner of its combination with glycerol or to the presence of some other optically active constituent. This is especially interesting in the case of *Pangium edule,* which will be discussed in the next section.

FRACTIONATION OF THE ETHYL ESTERS

In the preceding section certain tests have been shown to be valuable in distinguishing the chaulmoogra group of oils, in differentiating to some extent between the members of this group, and, in connection with clinical data, in judging roughly the therapeutic value of a given oil. These tests are not strictly analytical, however, and taken alone do not determine, quantitatively or qualitatively, any one constituent. The next step, reported in this section, was to effect a partial separation of the mixed fatty acids. A complete separation is such a difficult matter that it has not been attempted in this study, but the work on *Taraktogenos kurzii* and *Hydnocarpus wightiana* is being extended with the expectation of reporting the approximate quantitative composition of these in a later paper.

The most successful general method of separating fatty acids uses the difference in boiling point of the esters to separate acids of different numbers of carbon atoms, and the difference in solubility of certain salts or addition products to separate acids with differing degrees of unsaturation. In the case of commercial chaulmoogra oils Dean and Wrenshall [9] have modified this method in that they prefer to distill the acids instead of the esters, and crystallize the acids instead of their salts. Their immediate object was to obtain pure chaulmoogric and hydnocarpic acids rather than to find the percentage composition of the oils used.

For the present study direct crystallization of the acids was adopted, as being more rapid and nearly as effective as crystallization of the salts. The ethyl esters were distilled, rather than the acids, being as easy to prepare, much easier to distill, and not subject to as much decomposition during distillation. In order to cover the ten samples in a reasonable time only one

[9] Dean, A. L., and Wrenshall, R., Journ. Am. Chem. Soc. 42 (1920) 2626.

distillation was made of each, and four out of the six fractions were examined, each of the four being given a single crystallization. The separations are incomplete, but data have been obtained which already have a comparative value and will have a quantitative value when the composition of any one of the oils becomes known.

DETAILS OF THE METHOD USED

A mixture of 500 grams of the oil, 750 mils of 95 per cent alcohol, and 20 mils of sulphuric acid (specific gravity, 1.84) was put in a round-bottom flask fitted with a reflux condenser and boiled vigorously for sixteen hours. The resulting crude ester mixture was washed with water, and then with dilute sodium hydroxide, making sure that a slight excess of sodium hydroxide remained after thorough shaking in the cold. The emulsion was broken up by heating, and the separated ester was thoroughly dried and weighed. The acidity of the dried ester mixture was then determined. (The weight should be at least 450 grams and the acidity not more than 0.2 per cent.)

Three hundred mils of the dried ester were distilled in vacuo in a standard Pyrex 500-mil Hempel distilling flask, the neck of which was filled with broken glass. Fractions of 50 mils each were collected. The temperature limits and pressure for each fraction were noted, and each was weighed.

The first, second, fifth, and sixth fractions were separately thoroughly saponified and the fatty acids set free. The freed acids from each were recrystallized from 200 mils of 80 per cent alcohol, cooling to about 15° C., and the filtrates again saponified and treated with acid. The crystals are designated (Tables 4, 5, 6, 7) by *a*, in addition to the appropriate fraction number, and the fatty acids (completely free from inorganic acid) from the alcoholic filtrates are designated by *b*.

The weight, freezing point, iodine number, and specific rotatory power in xylene of each fraction were recorded.

Fractions 3 and 4 of most of the oils were not tested, for the reason that they are intermediate fractions and the data gained do not appear worth the time consumed. The general tenor of the data on these fractions may be seen in Tables 6 and 7, where they are recorded for a few of the samples.

During the latter part of the work the pressure was regulated at 20 millimeters by an adjustable mercury trap.

TABLE 3.—*Characteristics of the oils.*

Sample.	Specific gravity $\frac{30\ ^{\circ}C.}{30\ ^{\circ}C.}$	Refractive index $n\ ^{30}_{D.}$	Freezing point, °C.	Rotation, 100 mm, 30 °/D.	Iodine number, Hanus.	Saponification number.	Acidity, as per cent oleic.	Fatty acids, freezing point, °C.	Fatty acid, specific rotatory power, $[\alpha]\ ^{30}_{D.}$
Gynocardia odorata, first grade	0.929	1.4743	4	0	160	198	2.7	20	0
Hydnocarpus alcalae, C:									
First grade	0.948	1.4763	24	48.3	94.0	202	6.7	55	40
Second grade							32.6		
Hydnocarpus anthelminthica, first grade	0.952	1.463	16	44.2	84.5	201	3.6	36	50
Hydnocarpus hutchinsonii:									
First grade	0.943	1.4743	23	44	83.5	199	5.3	43	50
Second grade			12		77.0	183	26	39	
Hydnocarpus subfalcata:									
A, first grade	0.951	1.4761	21	49.1	89.0	206	6.6	41	36
A, second grade							41		
B	0.956	1.4770	15	51.6	91.5	205	6.2	34	55
Hydnocarpus venenata:									
First grade	0.947	1.4769	20	46.4	90.7	191	1.2	47	49
Second grade							40.0		
Hydnocarpus wightiana:									
A, first grade	0.947	1.4763	11	51.2	97.0	207	6.7	40	54
A, second grade							27		
B	0.950	1.4772	13	50.1	99.1	204	6.3	39	54
C	0.948	1.4769	11	51.4	101	204	15.1	35	56
Hydnocarpus woodii, A, first grade		1.473	18	45.9	68.5	192	5.9	43	53
Pangium edule, B:									
First grade	0.925	1.472	7	16.9	78.5	200	6.9	18	17
Second grade		1.467	4	2.8	75.0	181	21	17	2

Taraktogenos kurzii:									
A, first grade	0.951	1.4771	9	43.5	104	215	3.4	32	43
A, second grade							74		
B	0.948	1.4769	9	45.1	105	199	14.8	36	50
C	0.948	1.4765	14	51.2	102	203	18.8	39	58
D	0.946	1.4753	20	47.9	95	203	5.5	32	52
E	0.946	1.4753	20	47.5	95	204	4.5	28	51
F	0.947	1.4763	10	46.7	104	197	13.0	21	51
G	0.948	1.4764	8	46.2	97	203	22.6	28	51
H	0.951	1.4767	9	45.9	102	198	13.8	29	49
I	0.949	1.4762	18	46.3	96	187	14.9	22	48
J				47.2			4.1		
K	0.952	1.4770	5	45.7	105	204	14.6	26	47
L	0.948	1.4768	5	45.1	104	205	12.6	23	48
M	0.950	1.4762	7	44.9	102	204	15.5	24	48
N				26			39		

CHARACTERISTICS OF THE FRACTIONS

The results of the tests described in the preceding section are recorded in Tables 4, 5, 6, 7, 8, and 9. Instead of discussing the tables separately it will be found more convenient to take up the data of all six tables, column by column.

Samples.—The lettering or other designation of the samples indicates their correspondence with the samples mentioned previously in this paper.

Hydnocarpus alcalae, A, was distilled into five instead of six fractions. The fourth and fifth fractions are tabulated with fractions 5 and 6, because they are the last two fractions. Fraction 4 is accordingly lacking for this sample.

Taraktogenos kurzii, D and *F,* have small final fractions because of accidental difficulty in washing the crude ester and consequent lack of ester for distillation.

Pressure.—No appreciable decomposition takes place at 20 millimeters. Lower pressures are disadvantageous from the point of view of fractionation. In the cases where the pressures are different from 20 millimeters a rough correction of 1° per millimeter may be applied to the temperatures.

Temperature.—The temperatures are not corrected for stem exposure. They indicate that between the first and last fractions satisfactory separation was obtained, but otherwise are not of much value. Variations due to small leaks and other experimental difficulties mask differences which may be characteristic of the individual oils. *Hydnocarpus alcalae, B,* however, shows the relative constancy of boiling point which agrees well with the later data.

Weight.—Approximately 50 mils were collected in each fraction, but there was some accidental variation, as is shown by the column of weights. The shortages in *Taraktogenos kurzii, D* and *F,* Tables 8 and 9, were caused by the inadvertent use of too little ester for distillation.

Fatty acids; weight.—The weight given in column *b* for any fraction shows the solubility of the fraction in 200 mils of cold 80 per cent alcohol. It was difficult to secure uniform deposition in all samples due to such factors as retention of filtrate, supersaturation, re-solution of crystals while filtering, etc. As solubility figures, therefore, these columns are not very accurate, but they are necessary in connection with later figures to show the relative proportions of subfractions *a* and *b.*

Freezing point.—This was taken as described on page 553, and is very valuable in indicating the amount of liquid acid

present or the purity of the sample in hydnocarpic or chaulmoogric acid.

The fractional crystallization was not sufficiently thorough to demonstrate liquid acids, except in the case of *Pangium edule.*

Hydnocarpic acid is found in column *a,* Tables 4 and 5. *Hydnocarpus alcalae* is unique in giving chaulmoogric acid in these fractions, as is shown by the constancy of boiling point of the esters and the high freezing point in Table 6. *Pangium edule* gives no hydnocarpic acid, as is shown by the lack of optical rotation. The remaining oils all yield hydnocarpic acid. Taking into consideration the weights and freezing points of both *a* and *b* fractions it is evident that *Hydnocarpus anthelminthica* and *H. subfalcata* show a better separation of hydnocarpic acid than the other extracted oils. Not much difference can be noted between *Hydnocarpus wightiana* and *Taraktogenos kurzii,* but *Hydnocarpus hutchinsonii* appears somewhat inferior as a source of hydnocarpic acid. The pressed oils on the whole give indications of better yields than the extracted oils.

Chaulmoogric acid occurs in *Hydnocarpus alcalae* in very large proportion, as has been mentioned. The other oils show much less chaulmoogric without much variation among themselves.

Iodine number.—The Hanus method, one hour absorption, was used.

In the hydnocarpic acid fractions, Tables 4 and 5, both *a* and *b,* the iodine number is in general lower than the theoretical for hydnocarpic acid (100.7). There is considerable variation in different samples of the same oil, *Hydnocarpus anthelminthica* being the only oil definitely lower than the rest.

The chaulmoogric fractions, Tables 8 and 9, show a definite tendency toward a higher iodine number in the *b* fraction. This is quite variable in different specimens of the same oil, sometimes showing considerable amounts of acid more highly unsaturated than chaulmoogric.

In the case of *Pangium edule* it is evident that the solid acids are chiefly palmitic and stearic, as they have low iodine numbers.

Specific rotatory power.—The hydnocarpic fractions, Tables 4 and 5, show noticeable uniformity in rotatory power. The *b* fractions give somewhat lower figures than the *a* fractions, showing the presence of an inactive acid. This is especially true of *Hydnocarpus anthelminthica,* which evidently contains an appreciable amount of palmitic or a similar acid.

The chaulmoogric fractions, Tables 8 and 9, show higher rotation than the hydnocarpic, although the reverse is true of the

pure acids. (Power gives 58.6° for chaulmoogric acid and 68.1° for hydnocarpic.) *Hydnocarpus alcalae* and *H. subfalcata,* however, show notable amounts of stearic or a similar acid (by their low rotation), and all of the oils have some inactive acid which remains in the *b* fraction.

The absence of chaulmoogric and hydnocarpic acid in *Pangium edule* would seem to be definitely shown by this determination. It is possible, however, that these acids are present together with an enzyme which causes their destruction. Sample *A* of *Pangium edule* was insufficient for the ester distillation test, so sample *B* was prepared. After the absence of rotation in the esters of this sample was discovered it was found that the oil itself had no rotation. The second-grade oil of sample *A* (Table 3) has a very low rotation. Unfortunately we have no more seeds available for further work on this at present, but the evidence so far points to the absence of chaulmoogric and hydnocarpic acids in *Pangium edule.*

Saponification number.—It was hoped that this value would enable us to make the determination of the relative amounts of 16-carbon-atom and 18-carbon-atom acids in each oil. In general, the fractions 2 *b* and 5 *b* show higher saponification numbers (lower molecular weights) than the corresponding *a* fractions, as was expected, while fractions 1 *b* and 6 *b* are about the same as 1 *a* and 6 *a,* since fractions 1 and 6 are each fairly homogeneous, in respect of molecular weight, being end fractions in the distillation. There is evidently, however, some cause of variation in the saponification numbers, the nature of which we cannot definitely state, and which makes them unreliable as indications of the relative amounts of 16-carbon-atom and 18-carbon-atom acids in a fraction.

CONCLUSION

The foregoing data show a close similarity between the oil of *Taraktogenos kurzii* and all the *Hydnocarpus* oils that we were able to obtain. The only one of the latter that is distinctly different is *Hydnocarpus alcalae,* which contains a very large amount of chaulmoogric acid, and little or no hydnocarpic acid.

The other *Hydnocarpus* oils, like chaulmoogra oil, may each be separated into fractions (by the distillation of the ethyl esters) containing 16-carbon-atom acids and fractions containing 18-carbon-atom acids. The 16-carbon-atom fractions of each contain hydnocarpic acid and an unknown acid or acids which can be separated only very incompletely from the hydno-

TABLE 4.—*Characteristics of fraction 1.*

Sample.	Distillation.			Fatty acids.									
	Pressure.	Temperature.	Weight.	Weight.		Freezing point.		Iodine number.		Specific rotatory power $[\alpha]^{30}_{D}$.		Saponification number.	
				a	*b*	*a*	*b*	*a*	*b*	*a*	*b*	*a*	*b*
	mm.	°*C.*	*g.*	*g.*	*g.*	°*C.*	°*C.*						
Hydnocarpus alcalae:													
A, first grade	20	215–220	-----	12.9	6.2	42	29	80	82	46	40	-----	-----
B, first grade	16	–214	34	10.0	15.5	61	37	80	86	51	48	209	216
Hydnocarpus anthelminthica, first grade	26	-----	42	11.5	27	50	39	83	64	46	35	235	225
Hydnocarpus hutchinsonii, first grade	23	220–223	42	19.5	15.5	39	35	78	81	47	49	215	203
Hydnocarpus subfalcata, A, first grade	20	205–218	42	6.0	28	47	41	83	85	46	49	207	214
Hydnocarpus wightiana:													
A, first grade	20	210–218	49	26.8	18.5	41	38	86	86	49	46	192.5	223
C	20	211–214	40	29	12.5	48	38	99	105	60	53	214	206
Pangium edule, B, first grade	20	–218	45	6.2	27.5	51	7	26	85	0	0	219	222
Taraktogenos kurzii:													
A, first grade	20	205–217	40	2.0	28.0	45	33	90	86	51	42	213	218
D	20	215–218	35	12.5	20.6	48	40	91	90	55	47	-----	-----
F	20	205–214	52	11.8	19.8	41	25	91	99	54	41	214	209
G	20	209–218	45	11.5	17.0	42	34	93	94	52	45	215	216

TABLE 5.—*Characteristics of fraction 2.*

Sample.	Distillation.			Fatty acids.									
	Pressure.	Temperature.	Weight.	Weight.		Freezing point.		Iodine number.		Specific rotatory power $[\alpha]^{30}_{D}$.		Saponification number.	
				a	*b*	*a*	*b*	*a*	*b*	*a*	*b*	*a*	*b*
Hydnocarpus alcalae:	*mm.*	°*C.*	*g.*	*g.*	*g.*	°*C.*	°*C.*						
A, first grade	20	220–225	------	11.9	17.3	59	34	82	87	55	46	------	------
B, first grade	16	214–214	35	14.5	14.0	61	37	78	79	52	48	208	213
Hydnocarpus anthelminthica, first grade	26	------	44	4	30	49	41	75	78	53	39	228	223
Hydnocarpus hutchinsonii, first grade	22	223–224	42	15.0	21.0	37	35	75	87	52	52	195	204
Hydnocarpus subfalcata, A, first grade	20	218–221	43	15.7	20	44	42	71	87	50	44	217	216
Hydnocarpus wightiana:													
A, first grade	20	218–219	46	35	7.0	38	33	86	96	48	42	178	210
C	20	214–214	42	27.0	10.0	41	40	94	103	57	58	205	209
Pangium edule, B, first grade	20	218–221	44	3.2	30.0	50	15	22	80	0	0	206	216
Taraktogenos kurzii:													
A, first grade	20	217–220	43	13.5	22.5	41	32	91	87	51	42	213	216
D	20	218–218	37	12.0	23.5	49	41	92	88	58	49	------	------
F	20	214–217	51	25.6	25.6	40	25	90	100	54	50	211	208
G	20	218–218	44	17.0	14.0	44	26	92	97	56	45	220	206

TABLE 6.—*Characteristics of fraction 3.*

Sample.	Distillation.			Fatty acids.									
	Pressure.	Temperature.	Weight.	Weight.		Freezing point.		Iodine number.		Specific rotatory power $[\alpha]^{30}_{D}$.		Saponification number.	
				a	b	a	b	a	b	a	b	a	b
	mm.	°C.	g.	g.	g.	°C.	°C.						
Hydnocarpus alcalae, A, first grade	20	225–230	51	19.8	13.5	64	34	91	102	56	49	-----	-----
Hydnocarpus wightiana, C	20	214–216	40	29.1	21.0	37	36	90	106	53	54	191	209
Taraktogenos kurzii:													
D	20	218–219	42	27.0	12.1	46	39	91	93	55	46	-----	-----
F	20	217–220	47	7.0	17.7	51	26	89	101	50	50	186	198
G	20	218–219	42	9.5	16.5	43	32	95	107	59	50	211	207

TABLE 7.—*Characteristics of fraction 4.*

Sample.	Distillation.			Fatty acids.									
	Pressure.	Temperature.	Weight.	Weight.		Freezing point.		Iodine number.		Specific rotatory power $[\alpha]^{30}_{D}$.		Saponification number.	
				a	b	a	b	a	b	a	b	a	b
	mm.	°C.	g.	g.	g.	°C.	°C.						
Hydnocarpus wightiana, C	20	216–219	40	22.0	17.5	43	40	101	109	59	54	211	209
Taraktogenos kurzii:													
D	20	219–224	45	6.0	34.0	40	38	94	96	52	52		
F	20	220–224	47	19.5	23.3	53	27	95	121	51	54		199
G	20	219–226	47	7.5	18.8	49	31	103	105	52	47	204	202

TABLE 8.—*Characteristics of fraction 5.*

Sample.	Distillation.			Fatty acids.									
	Pressure.	Temperature.	Weight.	Weight.		Freezing point.		Iodine number.		Specific rotatory power $[\alpha]^{30}_{D}$.		Saponification number.	
				a	*b*	*a*	*b*	*a*	*b*	*a*	*b*	*a*	*b*
Hydnocarpus alcalae:	*mm.*	°*C.*	*g.*	*g.*	*g.*	°*C.*	°*C.*						
A, first grade	20	230–232	-----	33.4	13.2	64	38	92	144	58	49	-----	-----
B, first grade	16	216–219	38	25.5	6.0	67	18	91	110	60	46	201	201
Hydnocarpus anthelminthica, first grade	26	-----	50	23.5	20	60	29	79	83	46	-----	208	221
Hydnocarpus hutchinsonii, first grade	19	227–227	38	18.0	17.5	63	35	81	99	58	48	195	206
Hydnocarpus subfalcata, *A*, first grade	20	223–229	40	11.0	27	59	34	90	85	48	38	209	191
Hydnocarpus wightiana:													
A, first grade	20	223–231	43	13	26	65	29	96	100	60	49	197	217
C	20	219–223	40	18.5	17.5	55	38	104	110	58	57	204	210
Pangium edule, *B*, first grade	20	223–225	43	1.8	31.5	57	7	37	101	0	0	179	211
Taraktogenos kurzii:													
A, first grade	20	227–231	40	7.0	26.3	57	31	92	85	49	42	195	204
D (214.5 g. used)	20	224–230	17	5.0	10.0	61	38	89	101	56	49	-----	-----
F	20	224–226	44	25.3	16.0	59	28	91	138	52	54	173	199
G	20	226–232	40	12.0	4.6	63	26	113	108	54	52	204	200

TABLE 9.—*Characteristics of fraction 6.*

Sample.	Distillation.			Fatty acids.									
	Pressure.	Temperature.	Weight.	Weight.		Freezing point.		Iodine number.		Specific rotatory power $[\alpha]^{30}_{D}$.		Saponification number.	
				a	*b*	*a*	*b*	*a*	*b*	*a*	*b*	*a*	*b*
Hydnocarpus alcalae:	*mm.*	°*C.*	*g.*	*g.*	*g.*	°*C.*	°*C.*						
A, first grade	20	232–		24.4	3.4	55	44		137	-	-	-	-
B, first grade	16	219–	29	18.0	8.0	65	29	86	86	59	41	199	216
Hydnocarpus anthelminthica, first grade	26		47	4.9	32.4	52	37	79	90	41	43	223	225
Hydnocarpus hutchinsonii, first grade	18	227–233	35	22.0	9.5	66	35	81	101	63	48	194	201
Hydnocarpus subfalcata, *A*, first grade	20	229–238	59	40.2	16.0	62	37	90	90	44	34	204	210
Hydnocarpus wightiana:													
A, first grade	20	231–234	30	12.5	21.5	64	36	95	92	52	35	203	205
C	20	222–229	50	40	10	54	29	99	124	53	51	184	186
Pangium edule, *B*, first grade	20	225–237	40	2.0	28.5	52	5	43	90	0	0	177	197
Taraktogenos kurzii:													
A, first grade	20	231–242	52	14.5	28.9	59	28	91	83	47	39	208	206
D	20	230–232	20	11.2	6.0	61	38	99	102	55	47	-	-
F	20	226–226	8	5.0	1.6	61		101		54	-	203	-
G	20	232–	21	6.3	7.6	58	16	92	98	48	43	203	193

carpic by one crystallization from 80 per cent alcohol. This unknown acid portion is optically inactive or at least less active than hydnocarpic. The 18-carbon-atom fractions contain chaulmoogric acid, which can be separated out more readily than can the hydnocarpic above mentioned. A more highly unsaturated portion is left, in the case of many samples, when the chaulmoogric acid is crystallized out.

No reason appears for considering chaulmoogric oil to be superior to the *Hydnocarpus* oils in general for therapeutic purposes. Clinical data on this point, however, are lacking, and must be obtained before any positive statements can be made. Even more important is the clinical study of the various components of the hydnocarpus oils, as it is probable that when the effects of each is well known better therapeutic results can be obtained than are possible at present.

Brill's results on *Gynocardia odorata* were evidently due to a confusion of this seed with that of *Taraktogenos kurzii*, which confusion still exists in Assam in spite of the ease with which the seeds can be distinguished.

Brill's conclusion that chaulmoogric or hydnocarpic acid is contained in *Pangium edule* is rendered doubtful by our experiments. Some variable optically active constituent is contained in the fatty acid fraction, however, possibly the above-mentioned acids together with a destructive enzyme.

SUMMARY

1. The analytical data existing in the literature on the chaulmoogra group of oils have been summarized and found to be qualitative and incomplete.

2. Authenticated seeds of ten species related to chaulmoogra and fifteen samples of commercial oils were studied for the purposes of (*a*) establishing criteria for the recognition of each oil and for the detection of adulteration, (*b*) sufficiently separating each oil into its components to enable its evaluation as a potential source of hydnocarpic acid, chaulmoogric acid, or other therapeutically valuable constituents, and (*c*) determining economically important data.

3. The seeds were graded and extracted by solvents. The oils thus obtained as well as the commercial oils were examined for specific gravity, refractive index, freezing point, optical rotation, iodine absorption, saponification number, and acidity, and their fatty acids for freezing point and specific rotatory power.

4. Thirteen of the above-mentioned oils were partially resolved by the fractional distillation of the ethyl esters of their fatty acids followed by a crystallization of the recovered fatty acids from each of four fractions. The eight resulting fatty acid fractions from each oil were examined for freezing point, iodine absorption, specific rotatory power, and saponification number.

5. Previous results placing *Gynocardia odorata* outside of the chaulmoogra group have been confirmed. *Pangium edule* appears to contain no chaulmoogric or hydnocarpic acid.

6. *Hydnocarpus alcalae* was found, in confirmation of Brill's results, to contain a large amount of chaulmoogric and little or no hydnocarpic acid. The remaining *Hydnocarpus* oils studied were found very similar to chaulmoogra in chemical composition.

ILLUSTRATION

[Photographs by the Bureau of Science.]

PLATE 1.

FIG. 1. Seeds of *Hydnocarpus subfalcata* Merrill, from Zambales, P. I.
2. Chaulmoogra-group seeds, Philippine and foreign.
   a. *Taraktogenos kurzii* King, true chaulmoogra, from Assam.
   b, *Hydnocarpus alcalae* C. de Candolle, dudu-dudu, from Albay, P. I.
   c, *Hydnocarpus hutchinsonii* Merrill, mansaloka, from Zamboanga, P. I.
   d, *Hydnocarpus anthelminthica* Pierre, lukrabao, from Cambodia.

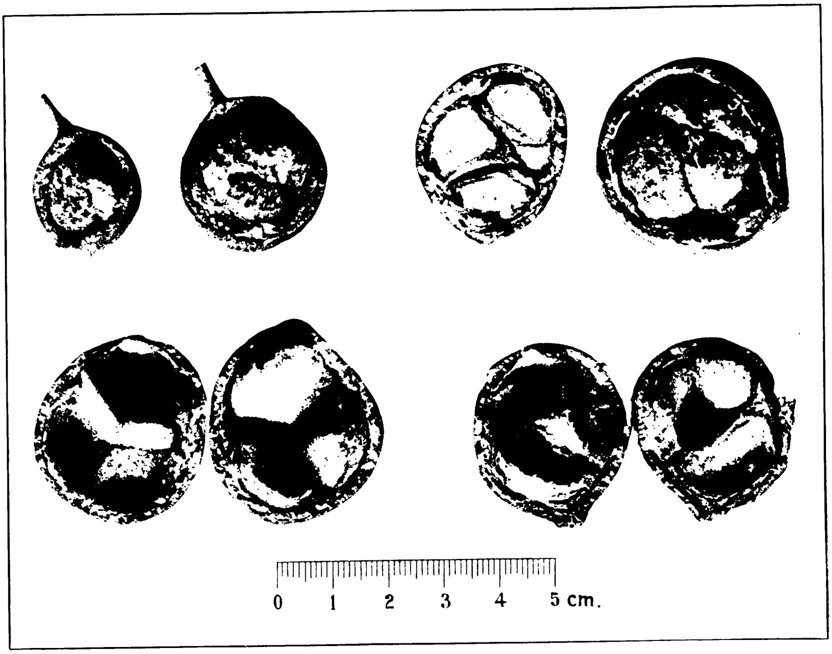

Fig. 1. Seeds of Hydnocarpus subfalcata, from Zambales.

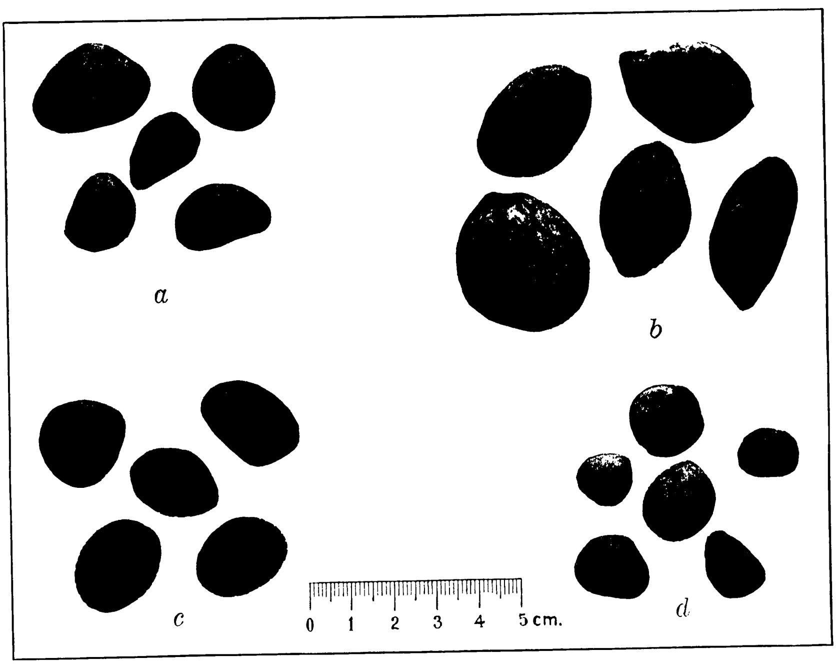

Fig. 2. Chaulmoogra-group seeds, Philippine and foreign.

PLATE 1.

A NEW PHILIPPINE BIKKIA

By TH. VALETON
Of Leiden, Holland

BIKKIA PHILIPPINENSIS sp. nov.

Frutex habitu generis. Ramulus 6 mm crassus, medio defoliatus et fructifer, internodiis brevibus, foliis cum floribus axillaribus versus apicem confertis. Stipulae in annulum connatae, apice brevi-apiculatae et subcarinatae. Folia elliptico-lanceolata (major 11×3.5 cm), apice obtusa acute submucronata, basi attenuata in petiolum decurrentia, mediocrem, in sicco crasse rigide coriacea, ochracea, costa lata nervis subimmersis. Flores tetrameri ceterum iis *B. grandiflorae* similes, corollae tubo proratione magis elongato. Calycis lobi late lanceolati ancipites, acuti, circiter 10 mm longi, post anthesin elongati, ovarium longitudine aequantes. Corollae tubus (in alabastro maturo) 50 mm longus, sensim in limbum angustum dilatatus. Lobi trigoni acuti, lateraliter leviter emarginati. Ovarium argute costulatum, biloculare. Placenta in quoque loculo lamelliformis apice bifida ramis appressis vel demum recurvis et incrassatis extus ovuligeris. Capsulae parvae, 28 mm longae, bivalvae, valvis fere ad medium usque fissis, demum epicarpio denudatis et contortis, apice 20 mm latis, obtrigonis; fibrae epicarpii 8, filiformes.

CEBU, Mualbual, *Elmer 12052*, October, 1909. (The same species is also represented by *Merrill 5297* from Sibutu, Sulu Archipelago, and *Bur. Sci. 34428, 34583 Ramos & Pascasio*, Surigao Province, Mindanao. All specimens were originally determined as *Bikkia grandiflora* Reinw.—E. D. M.)

In habit this species is strikingly similar to *Bikkia grandiflora* Reinw., but the 4-fid fruit, the bifid valves of which are wholly detached from the placenta, and the structure of the ovary indicate that its proper place is in the subgenus *Eubikkia;* the type of this subgenus is *Bikkia tetrandra* A. Gray, based on *Portlandia tetrandra* Forst. from Savage Island. *Bikkia grandiflora* Reinw., from the structure of its ovary and its fruit, belongs in the subgenus *Bikkiopsis,* which is typified by *B.*

pancheri Deplanche of New Caledonia. To this subgenus *B. commersoniana* K. Schum. belongs, as demonstrated by Schumann, and to it must also be referred the type of the genus, *Bikkia grandiflora* Reinw., which up to the present time I, as well as other authors, had supposed to be identical with *Portlandia tetrandra.* To the section *Eubikkia,* in addition to *B. philippinensis* and *B. tetrandra, B. mariannensis* is to be referred, as well as an unpublished species from the Palau Islands. To *Bikkiopsis* are to be referred all of the species from the Moluccas and New Guinea and some of those from New Caledonia.

TREATMENT OF LEPROSY WITH ANTIMONY [1]

By JOSÉ RODRIGUEZ and FROILAN EUBANAS

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INTRODUCTION

The best of the newer methods of treating leprosy fall so far short of what is hoped will be ultimately attained that any therapeutic measure that may be of value, whether as an auxiliary to the chaulmoogra preparations or in their stead, should be tested thoroughly. It was for this reason, and without prejudice in the matter, that when encouraging reports on the use of antimony preparations were brought to the attention of the Culion authorities by Doctor Cawston, of Natal, we were requested to try them out on cases under our care.

Cawston [2] reported remarkable results obtained in Natal with tartar emetic and a proprietary colloidal preparation of antimony known as oscol stibium, though he stated that the tartar emetic can be given with benefit by mouth in the form of vinum antimonii. He claimed that paralyses were relieved, ulcers dried up, and the general condition of the patient improved within a remarkably short time. He also noted relief in the various eye complications so commonly seen in this disease. Wildish [3] obtained. similar results in the Amatikulu Leper Institution in Zululand, and concluded that antimony is of very decided value in the treatment of leprosy, more particularly in cases exhibiting severe manifestations of the disease.

TARTAR EMETIC ADMINISTERED INTRAVENOUSLY

A simple, 1 per cent solution of tartar emetic in distilled water was given intravenously to a group of inmates of the General Hospital of the Culion Leper Colony for a period of six months. The solution was always freshly prepared as it tends to precipitate after a few days. Sterilization was effected by flowing

[1] Published with the approval of the Philippine Leprosy Research Board and the consent of the Director of Health.

[2] Cawston, F. G., Brit. Med. Journ. No. 3107 1 (1920) 76, 77; No. 3127 2 (1920) 855, 856; No. 3142 1 (1921) 419.

[3] Wildish, G. H., Brit. Med. Journ. No. 3185 1 (1922) 55.

steam, Castellani[4] having advised against heating under pressure.

Thirty-one patients were selected from among the best-nourished inmates of the wards. Under the system followed in this colony chiefly advanced cases that require hospital care on account of deformities, or treatment of complications and sequelæ, are assigned to the General Hospital. Among those chosen for the experiment eight showed signs of pulmonary tuberculosis; only one of these was given the treatment for the full period of the experiment.

Thirty of the cases were lepers; one, found to have ulcerative tertiary yaws, received injections for two months before she was sent home. Though eliminated from consideration as a leper, this case served to some effect as a control.

In most of the cases the disease was advanced. Efforts were made to represent all types and degrees of ulcerations, contractures, deformities, and eye complications. None of the cases could be classified as pure cutaneous. Seven were neural, and twenty-three mixed. The ages are given in Table 1; the majority were above 30 years of age, and 36 per cent were in the fourth decade. The duration of the disease is shown in Table 2. The greatest duration was twenty-two years, the shortest two, and the average eleven.

TABLE 1.—*Age distribution of cases treated.*

Age. Years.	Cases.
To 15	1
16 to 20	5
21 to 30	6
31 to 40	11
41 to 50	3
51 to 60	4
Total	30

TABLE 2.—*Duration of leprosy in cases treated.*

Duration. Years.	Cases.
4 or less	2
4 to 8	5
8 to 12	14
12 to 16	6
16 to 20	2
20 to 22	1
Total	30

[4] Castellani, A., and Chalmers, A. J., Manual of Tropical Medicine 3d ed. (1920) 1297.

In the preliminary examination, cutaneous sensibility to light touch, deep touch, heat and cold, and pain was determined and charted. Nodules, contractures, eye lesions, and other features of interest were described and in many cases photographed. The ulcers were counted and the more prominent ones measured. Bacteriological examinations were made from the cutaneous lesions or, in the absence of such, from the nasal septum. The acuteness of vision in those presenting involvement of the eyes was also tested. The urine of each was examined at least four times during the period; before starting treatment, after two months, after four months, and at the completion of the experiment.

TREATMENT

During this period no other treatment was given that could obscure the results. Ulcers were washed with weak potassium permanganate solutions and dressed daily, as were those of others in the wards. The patients were maintained under exactly the same general conditions as were the others, who therefore served in a way as controls.

The doses of the drug tolerated by our cases were much lower than those used in other tropical diseases such as kala-azar, sleeping sickness, etc., in which as much as 10 milliliters of the 1 per cent solution is injected daily for ten or more days. To avoid irritation of the kidneys, since chronic nephritis is common among Culion lepers, the first dose was fixed at 0.5 milliliter, or 0.005 gram of tartar emetic. This was increased by 0.5 milliliter at each weekly injection, up to 2.5 milliliters, or 0.025 gram. With this dose most of the patients became weak, complained of various ill effects, and urine examination revealed evidence of kidney injury in the majority of cases. The amount of the dose was then reduced to 1.5 milliliters, or 0.015 gram, with which dose most of the objectionable side effects were no longer noticed. In three cases the urine cleared up under this dose.

As the larger dose was clearly harmful, an attempt was made to give the drug more frequently in smaller amounts. This was tried on two patients who were already showing signs of improvement; the results proved disastrous as shown by the following notes:

Case 10.—N. T. Ulcers improving up to the ninth injection of 2.5 milliliters. Patient began to cough, and ulcers to return, so dose was reduced to 2 milliliters and, finally, to 1.5 milliliters, when improvement began again. After four injections at this dose the interval was reduced

to three days. After six such injections of 1.5 milliliters he began to have persistent abdominal pain, diarrhœa, prostration, and finally passed blood per rectum. Injections were suspended and the diarrhœa disappeared without any other treatment.

Case 11.—P. C. After the first two injections the ulcers began to heal, but on increasing the dose to 2.5 milliliters they began to break out again, and albumin appeared in the urine. After a brief rest the injections of 1.5 milliliters were resumed and the ulcers again improved. The injections were then given every three days. After six injections the patient became very weak, the old ulcers broke out afresh all over the body, and a large one appeared in the larynx, which made swallowing very difficult. The drug was discontinued and the ulcers improved, but that of the larynx persisted and the patient died in less than a month. Autopsy was not performed.

As a result of these experiences the dose usually given thereafter was 1.5 milliliters per week, though in some cases it was occasionally increased to 2 milliliters.

RESULTS OF TREATMENT

Of the thirty cases of leprosy put under treatment, five died before the end of the experiment, that is, within six months. Another died two weeks after its conclusion; in the discussion below this case is not included among those surviving at the end of the experiment. The mortality during the experimental period was, therefore, 16.1 per cent; the sixth death brings it up to 19.3 per cent. The results obtained in the survivors are shown in Table 3.

TABLE 3.—*Results of treatment in the twenty-four surviving cases.*

Result.	General condition.	Leprotic lesions.	Ulcers.
Much improved	0	0	1
Improved	2	0	5
Not improved	15	23	14
Worse	7	1	4
Total	24	24	24

General condition.—The results, so far as the general condition is concerned, are quite unsatisfactory. Not only did none of the survivors show much improvement, but a large proportion of them became worse during the experiment.

Leprotic lesions.—No improvement whatever could be seen in the leprotic lesions. No case in the series became bacteriologically negative.

In only one case (Case 21) did the injection induce the phenomenon known as lepra fever. On two occasions in this case severe exacerbations of the disease occurred. Numerous small nodules appeared all over the body and these ulcerated within a few days, so that it seemed as if practically the entire integument was converted into an oozing sore. This patient died suddenly two weeks after the end of the experimental period.

Ulcers.—There was apparent improvement of the ulcers in six cases, 25 per cent of the survivors; in fourteen, 58 per cent, they showed no change; in four, 1 per cent, they became distinctly worse.

It seems that the results with ulcers were influenced by two factors besides the drug itself, namely, the duration and the type of the ulceration. Table 4 gives the figures on the relation of duration and improvement.

TABLE 4.—*Relation of duration of ulcers and their improvement.*

Duration of ulcers.	Cases.	Improved.		Stationary.		Worse.	
Years		*Number*	*Per cent*	*Number*	*Per cent*	*Number*	*Per cent*
1 to 2	14	7	50	5	36	2	14
3 to 4	7	1	14	4	57	2	29
5 to 6	7	0	0	5	71	2	29
Over 6	2	0	0	2	100	0	0
	30	8	27	16	53	6	20

In half of the cases that had suffered from ulcerations for from one to two years improvement was noted, whereas none was noted in those of over four years duration.

As to the type of ulcer, the best results were noticed in the superficial ulcerations affecting the soles of the feet. In all four cases presenting this type, they were improved. Some improvement was also noticed among those having infected generalized lepromatous ulcers as shown in Table 5.

TABLE 5.—*Type of ulcer and results of treatment.*

Type of ulcer.	Improved.	Stationary.	Worse.	Total.
Infected lepromatous	5	9	5	19
Superficial plantar	4	0	0	4
Of foot, with sinus	0	4	0	4
Total	9	13	5	27

Two cases of clavus and of leprotic adenitis showed no improvement.

There is no indication of greater improvement with larger dosage. On the contrary, none of the ten patients receiving the highest average doses per injection were improved in any respect. Five of the six deaths are included among these ten; only three finished the experiment; the rest had to be dropped.

UNTOWARD EFFECTS OF TREATMENT

Twenty-three of the leprosy patients showed ill effects of some kind or other and only seven remained free. Table 6 gives all such symptoms observed.

TABLE 6.—*Untoward effects of treatment in leprosy cases.*

Symptom.	Cases.	Occurrences.
Systemic:		
General weakness after injection	9	19
Fever after injection	22	34
Chill	7	14
Exacerbation of leprotic lesions	1	2
Nervous system:		
Headache	11	25
Sensation of heat without fever	2	2
Neuralgic pain	3	6
Insomnia	1	4
Digestive system:		
Abdominal pain	4	4
Diarrhœa	3	5
Transient epigastric pain	2	2
Nausea	2	2
Respiratory system:		
Exacerbation of cough	3	10
Chest pain	3	12
Hæmoptysis	1	1

The commonest reaction was a brief slight fever that appeared a few hours after injection. This occurred thirty-four times. The fever seldom rose higher than 38° C. and was discovered only by taking the temperature as a matter of routine. The next commonest complaint was headache, which was rather severe at times. This was observed twenty-five times in eleven of our patients. Nine complained of general weakness after injection; this occurred nineteen times, usually accompanied by slight dizziness. Chill a few minutes after injection was occasionally observed. Nausea was noticed only twice. The nonleper had slight fever following an injection once during the period.

The most serious reaction was diarrhœa with abdominal pain. These symptoms were complained of by three patients, two of whom died. Treatment was stopped in the third case and apparently a fatal termination was averted; the diarrhœa disappeared without further treatment. When, in the course of a series of injections with tartar emetic, these symptoms appear, the drug should be discontinued at once. On the other hand, transient abdominal pain need not be taken seriously.

NEPHRITIS

The greatest drawback to the use of this drug in our cases was its effect on the kidneys. Examination of the urine as a routine measure at stated intervals brought to light evidence of kidney damage in a large proportion of the cases treated, in spite of the small doses used.

Twelve of those with negative urine at the start became positive for albumin within two months, though in most only traces were found. Casts appeared in four of these cases, and in one of them blood casts were observed, indicating the degree of irritation to which the kidneys had been subjected. Six had albumin at the outset; two of these died, one was dropped from treatment, in one the kidney condition cleared up, and in the other two it was aggravated. The nonleper showed no evidence of kidney injury.

TUBERCULOSIS

Eight patients showed evidence of pulmonary tuberculosis at the outset. One had hæmoptysis after receiving 8 milliliters in six injections. This case, together with three others who showed marked injurious effects, had been dropped within five weeks after starting; one of them died after having developed what was evidently a psoas abscess.

Only one of the eight tuberculous patients finished the six months course. The tuberculous process was accelerated in several cases, and in one markedly so, as confirmed by autopsy. Another died from persistent diarrhœa, apparently caused by the drug, not from the effects of the lung lesion.

SUBSEQUENT OBSERVATIONS

Six months after the conclusion of the experiment the surviving patients were reëxamined. Three had continued to improve, so far as the ulcerations were concerned; all of these had been taking chaulmogra oil by mouth since the end of the experiment. Three had become worse, and the rest remained stationary.

NOTES ON FATAL CASES

The following are notes on five of the six cases who died during the observation period. One, Case 10, N. T., has already been described.

Case 14, clinical features.—F. Y., male, 46 years old. Treatment was begun June 9, 1922. Patient fairly strong, though somewhat emaciated. Apices dull, bronchial breathing right, but no râles.

In four weeks six doses totaling 8 milliliters had been given. Complained of weakness, and hæmoptysis occurred on the day after the last injection. Dropped from treatment and gradually improved. Hæmoptysis did not recur. Two months later tenderness noticed in right iliac region over a mass which gradually became more superficial. Death a month later, when the mass, apparently a psoas abscess, seemed about to rupture. Unfortunately, autopsy was not performed.

Case 28, clinical features.—M. N., female, 34 years old. At beginning well nourished, apparently strong, though with fairly advanced pulmonary tuberculosis. Upper parts both lungs dull, with bronchial breathing and a few subcrepitant râles. After the fifth injection severe abdominal pain and diarrhœa developed, appetite completely lost, with marked prostration. A few days before death cough increased and fever became constant. The lung lesions had progressed very rapidly, with signs of cavity formation in both lungs.

Although severe abdominal pain was frequently complained of, there was no localized tenderness. Spleen and liver not felt. Urine became positive for albumin, but there was no œdema. Died two months and eight days after beginning treatment, having received but five injections in the first month.

Autopsy 78 (Dr. E. V. Pineda).—Upper lobe left lung almost completely destroyed by tuberculous cavitations. Right upper lobe contained cavities and also conglomerated tubercles. Numerous tubercles in lower lobes, both lungs. Indications are of a rapidly advancing process.

Spleen flabby and slightly enlarged, cut surface deep chocolate, marked increase in the stroma. Liver enlarged, soft, flabby, and friable, cut surface opaque, lobules rather indistinct. Nothing of interest in the alimentary tract. Genital organs congested and hypoplastic, otherwise negative. Kidneys slightly smaller and firmer than normal; on section cortex thin and slightly translucent, minute red vessels shining through. Capsule stripped with difficulty, tearing kidney tissue at points.

Diagnosis: Pulmonary tuberculosis, ulcerative and chronic miliary; pleuritis, chronic; nephritis, chronic; leprosy.

Case 18, clinical features.—S. V., female, 40 years old. Had ulcerations of feet and legs and dry gangrene of tips of the toes. Diarrhœa developed after beginning treatment, persistent and weakening. Also severe neuralgic pains along legs. Lungs markedly dull at apices, bronchial breathing, a few sibilant râles.

In twelve injections was given only 21.5 milliliters over a period of thirteen weeks. Urine showed traces of albumin before; after second month, cast found. Death occurred September 20, 1922, fifteen weeks after the beginning of experiment.

Autopsy 99 (*Dr. E. V. Pineda*).—Lungs filled with miliary tubercles. At apices conglomerated and surrounded by fibrosis. Peribronchial lymph nodes enlarged, black, rather soft; on cut surface a few grayish white tubercles. Heart slightly heavier than normal, pale, with a few yellowish glistening streaks in the muscle tissue. Spleen slightly larger than normal and flabby, grayish red, stroma markedly increased. Liver normal in size, slightly congested, cut surface rather opaque, lobules fairly distinct, with central congestion, tissue friable.

Kidneys normal in size, weight, and color of cut surface; cortex and medulla both thin. First portion of cæcum showed slight hyperplasia of lymphoid element, with a few petechial hemorrhages. Brain showed slight œdema of pia. Two ulcers found on epiglottis.

Diagnosis.—Pulmonary tuberculosis, chronic, miliary; nephritis, chronic (slight); multiple ulcers, skin; ulcers, epiglottis; leprosy.

Case 20, clinical features.—S. R., female, 43 years old. At beginning, apices dull and a few moist râles, right infraclavicular. A low systolic murmur was heard best at the base. Second pulmonic distinctly accentuated, but the murmur not transmitted to axilla and cardiac area not enlarged. Tender mass in right axilla. Patient anemic. Only traces of albumin in the urine; no œdema seen.

Patient under actual treatment for twenty-two weeks, receiving twenty injections totaling 32 milliliters. No untoward symptoms noticed, but occasional fever, headache, sometimes chest pain. After second and fourth months abundant albumin and casts found.

Died suddenly November 11, three days after the last injection of 1.5 milliliters. Complained of severe abdominal pain at midnight, vomited several times, dying within three hours.

During treatment the multiple superficial ulcerations much improved. An acute adenitis, right axillary, developed and burst; the fistula healed very slowly.

Autopsy 130 (*Dr. F. Solis*).—Axillary sinuses only important finding noted. Communicated with enlarged lymph nodes containing abundant caseous material liquefied centrally. In lungs, peribronchial nodes, heart, liver, kidneys, alimentary tract, and brain nothing pathological recognized. Spleen was smaller and firmer than normal, stroma reddish brown, distinctly increased.

Diagnosis.—Cause of death not determined. Adenitis, tuberculous; leprosy.

Case 21, clinical features.—P. S., female, 36 years old. Fairly well nourished. A few sibilant râles left interscapular, with impaired resonance. Slight œdema of legs; only traces of albumin in urine.

Injected twenty times in twenty-six weeks, totaling 34 milliliters. After second month urine loaded with casts, and albumin heavy. Œdema not more marked. Twice severe lepra reaction developed, principally fever and generalized papules that soon ulcerated but healed completely in remarkably short time, two weeks.

Suddenly, two weeks after last injection, complained of severe abdominal pain with vomiting and collapse, rapid, soft pulse, subnormal temperature, extremities cold, sweat-covered. Restless, moaned continuously, but answered questions fairly well. Face livid, respiration shallow and accelerated. Lungs dull at apices, with bronchial breathing right. No

râles. A systolic murmur at apex, not transmitted to axilla. Cardiac area not enlarged. Heart beats faint, rapid but regular. No localized resistance or tenderness in abdomen. Spleen and liver not felt. Reflexes normal. No œdema. Died after six hours, in spite of treatment.

Autopsy (*Dr. E. V. Pineda*).—Heart slightly larger than normal, musculature grayish red, but endocardium opaque and grayish white. No definite tuberculosis, but slight fibrosis, right apex. Spleen normal in size, wrinkled, stroma markedly increased. Liver congested, deep red, cut surface darker than normal, mottled. Alimentary tract normal throughout. Kidneys normal in size, and slightly softer than normal. Cortex thin, pale, with a few cortical cysts. Capsule stripped off with slight difficulty, tearing surface at points.

Diagnosis.—Nephritis, chronic, slight; leprosy. Immediate cause of death not determined.

Histologically (Doctor Pineda) kidneys showed chronic parenchymatous nephritis; heart cloudy swelling; spleen chronic interstitial splenitis with miliary lepromata; liver chronic passive congestion, slight proliferation of bile ducts, and miliary lepromata. Sections of lung examined normal.

TARTAR EMETIC IN LEPRA FEVER

Tartar emetic by mouth has been tried out by certain members of the staff at Clinic 2, in the treatment of the so-called lepra fever. It was given in a mixture of sodium salicylate and sodium bicarbonate, in doses that represented 8 centigrams of the tartar emetic per day.

It has been possible to gather data on twenty-nine cases of lepra fever treated solely with this formula, receiving from 0.24 to 1.96 grams of tartar emetic during the treatment. The average duration of stay in the hospital for these cases was twenty-seven days, four days more than the average hospitalization for 1922 in this clinic, which was reported as twenty-three days.

Two cases in this group died; these had chronic nephritis on admission to the hospital. One of them developed uremic symptoms after ten days of treatment, during which time he had received about 0.9 gram of the drug. The other was given 1.80 grams in twenty-five days before he died, the prominent symptoms toward the end being progressive weakness, loss of appetite, drying up of ulcers, and vomiting.

In four other cases œdema of the legs and albumin in the urine were noticed during the treatment. One of these received only 0.24 gram, the second 0.32 gram, the third 0.56 gram, while the amount given the fourth could not be determined.

It is not possible, for lack of control observations, to say positively whether these patients improved more rapidly or less

rapidly under this treatment than they would have done without it. Comparison of the figures given with those of Clinic 1, where the medication was not given, is unsatisfactory. Here, fifty cases of lepra fever had an average hospitalization of twenty-one days, six days less than the Clinic 2 group, but six days more than the reported 1922 hospitalization average of fifteen days, which is more than the four-day extra period of Clinic 2.

The data from the two clinics are, unfortunately, not directly comparable, as there are important differences in the cases registered. Clinic 1, established a year earlier, has many of the more favorable cases, whereas Clinic 2 has a high proportion of advanced cases of long duration, less favorable for treatment. The only conclusion that can be drawn is that tartar emetic in these cases was without any striking benefit. As a matter of fact, this method of treatment was discontinued because there was not only no evidence of improvement as a result of it, but distinct evidence of injury to the kidneys.

TREATMENT WITH ANTIMONY WINE

While the experiment with tartar emetic administered intravenously was in progress, a cough mixture containing wine of antimony was given to twelve other General Hospital cases. Most of them had cough due to pulmonary tuberculosis; two had probable leprotic ulceration of the larynx, the lungs being negative. The doses were equivalent to from 2 to 3 milliliters of the wine daily, or 0.008 to 0.012 gram of tartar emetic. The treatment was continued for six months.

Of the cases put under treatment, two left the hospital after a short time, and one was dropped because of chronic nephritis. Of the remaining nine, two showed improvement of the cough, two remained practically stationary except for slight improvement of ulcers, two became distinctly worse, both as regards the cough and the ulcerations, and three died. None showed improvement of the leprotic lesions at the end of the six months.

Antimony wine was also given undiluted to another group of ten patients of similar type. The dose was 3 cubic centimeters a day at the start; this was gradually increased until some were taking as much as 9 cubic centimeters per day, equivalent to 0.036 gram of tartar emetic. At this dose it caused nausea and occasional diarrhœa. It was administered for periods of fifteen days with five rest days between, over the six months.

Four of the ten were dropped after a month because they flatly refused to continue taking the drug. They had suffered nausea and weakness, even with the initial dose. At the end of the period two showed some improvement in the ulcerations, but the remaining four were exactly the same as before treatment, so far as could be determined; the leprous lesions seemed in no way affected.

CASTELLANI MIXTURE

In connection with the trial of tartar emetic as a treatment in leprosy it seemed of interest to determine whether the formula proposed by Castellani for treating yaws would be of benefit in leprosy. It contains not only tartar emetic, the effect of which on leprosy it was desired to test particularly, but also a fairly large amount of potassium iodide. This has been used variously in leprosy, particularly after Danielson's advocacy of it and, while it has long since been discarded as a means of treatment, it is still cited as an agent for exciting a reaction that may be of service in diagnosis. It was possible that in the combination used this effect might prove beneficial.

CASES TREATED

Twelve General Hospital patients were put under this treatment, most of them bedridden cases. One of these, who had tuberculosis, had to be dropped after eleven doses because of exacerbation of the lung lesions. There were eight males and four females. Incidentally, this is the proportion existing in the general population of the Culion Leper Colony, according to the colony statistics. The age varied considerably; one was 20 years old, five were between 20 and 30, four were between 30 and 40, and two were between 40 and 50. The average was a little over 31 years, undoubtedly considerably higher than that of the total colony population.

Three cases were classified as pure cutaneous, one as neural, and the remaining eight as mixed, the commonest type among well-advanced cases. In only one case was the duration less than five years; in this it was three. In five it was six to eight years, in four it was ten to twelve, in one it was sixteen, and in one it was thirty-two years. The average, approximately eleven years, is high for the colony, but not particularly so for the inmates of the General Hospital. In two cases the disease was advanced, in the rest it was moderately advanced. Five had no ulcers, another five of the cases had only a few, from one to five in number, and in only two were they numerous.

FORMULA AND DOSAGE

The formula used in this experiment was the revised one of Castellani [5] except that the amounts of glycerine and water were increased from 8 and 22 milliliters to 40 and 60 milliliters, respectively:

R/ Tartar emetic	0.065	gm.
Sodium salicylate	0.650	"
Potassium iodide	4.000	"
Sodium bicarbonate	1.000	"
Glycerine	40.000	ml.
Aqua q. s. ad	60.000	ml.

The above amount was given in two days, the patient taking 15 milliliters of the mixture, diluted with water, twice daily. Each dose thus contained 1.625 centigrams of tartar emetic and 1 gram of potassium iodide. In the treatment of framboesia with this mixture Castellani gives the full formula three times a day, and in the Philippines Guerrero [6] and his coworkers, after beginning with one-third dose three times on the first day, and giving a full dose twice on the second day, was able to give a full dose three times on the third and subsequent days.

The treatment was given for eight consecutive days, making a total of 240 milliliters in this period. The sixteen doses so given were considered a series, and one series was given each month for three successive months.

The medicine was given after meals to avoid as far as possible gastric irritation. For the same reason the dose was not increased, although in using a colloidal preparation of antimony, "oscol stibium," Cawston advises pushing the dosage until toxic symptoms, as diarrhœa, are seen. The administration of the medicine is not without difficulty, as even among nonlepers this mixture often upsets the stomach as observed in cases of yaws so treated.

Among the most important immediate after effects have been those referable to the irritation of the gastrointestinal tract. Lepra fever, with constitutional disturbances, has been another difficulty. When this occurred the medicine had to be stopped temporarily until the fever subsided. The bad taste of the medicine is in itself a difficulty, as it is intolerable to some patients, who sometimes refused absolutely to take it.

[5] Castellani, A., and Chalmers, A. J., Manual of Tropical Medicine, New York, 3d ed. (1920) 1563.

[6] Guerrero, L. E., Domingo, E., and Arguelles, M., Philip. Journ. Sci. § B 13 (1918) 191.

TOTAL AMOUNTS ADMINISTERED

Of the remaining ten cases one patient took thirty doses, representing practically 49 centigrams of the tartar emetic, and two took forty and forty-four doses, or 65 and 72 centigrams, respectively. Seven took the full forty-eight doses or more, six being given fifty-one to fifty-three doses, or 52 to 86 centigrams of tartar emetic. The potassium iodide taken by this main group amounted to 48 and 53 grams. One patient refused to continue the treatment after taking six doses. In another case with pulmonary tuberculosis treatment was suspended after eleven doses, on account of poor condition of the patient.

RESULTS OF TREATMENT

Though the total time involved was but three months, which is too short to expect much real improvement in well-advanced cases of leprosy, nevertheless it was felt that, were the treatment of much value, there would be some improvement by the end of that time. This expectation was based in large part on the reports referred to.

The results obtained were not encouraging. Neither in the general condition nor in the disease itself was there any marked evidence of improvement. The results are tabulated in Table 7 and summarized in Table 8.

TABLE 7.—*Result of treatment with Castellani mixture.*

Case No.	Type.	General condition.	Leprosy lesions.	Ulcers.
1	Mixed	Stationary	Slight improvement	None.
2	Cutaneous	do	do	Slight improvement.
3	do	do	do	Do.
4	Mixed	do	Stationary	None.
5	do	Worse	do	Stationary.
6	Cutaneous	Stationary	do	Do.
7	Mixed	do	do	Do.
8	do	Worse	do	None.
9	do	Stationary	do	Slight improvement.
10	do	do	do	Stationary.
11	Neural	do	do	None.
12	Mixed	do	do	Do.

TABLE 8.—*Summary of data in Table 7.*

	General condition.	Leprosy lesions.	Ulcers.
Slight improvement	0	3	3
Stationary	10	9	4
Worse	2	0	0

As regards the general condition, no patient claimed to feel better than before treatment, and in none was any evidence of improvement apparent. On the contrary, two cases were evidently worse, due to repeated attacks of lepra fever. Loss of appetite, a frequent complaint, may have had something to do with this general result.

The leprotic lesions in the majority of cases showed no signs of improvement. In three, however, two nodular and one mixed, there was slight improvement. This consisted of only slight thinning of the nodules and of some of the infiltrations on the face and extremities.

More improvement was noticed in the ulcerations than in any other feature. In three, 42 per cent of those with ulcers, there was some improvement. The ulcers that improved were not the trophic plantar lesion but the bacillus-containing ulcers of leprotic nodules. The improvement was slight and was manifested by slight drying up of the edges and shallowing of the ulcers. In no case did the ulcers become worse.

INCIDENTAL AND SIDE EFFECTS

Kidney.—Because of the constant necessity of considering the effect on the kidneys of such medication in the Culion lepers, the urine of each case was examined four times—before treatment was begun, and at the expiration of each of the three months. No evidence of kidney injury was observed. On the contrary, in two cases the urine, which at the outset contained small quantities of albumin, cleared up; so that in one of them it was not found again, and in the other only at the end of the first month.

Gastrointestinal tract.—Side effects referable to this system were salivation, epigastric heaviness, pain, nausea, and vomiting. Salivation was a frequent symptom complained of by all but two of the cases, but in no case was it marked. Epigastric heaviness was reported by eight of the cases, and epigastric pain by five, of which all but one were among those complaining of heaviness. Neither symptom was severe. Nausea of slight degree was recorded in patients who vomited, seven among the total cases, two repeatedly and five only occasionally.

Reproductive system.—In the majority of the cases there were no symptoms referable to the reproductive system but Cases 1 and 2 always complained of scrotal pains after taking the mixture for four to six days. Case 2 had an epididymo-orchitis probably of leprotic origin; the pain frequently be-

came so intolerable that the medication had to be suspended temporarily.

Reaction.—In the ordinary course of events in leprosy which, broadly speaking, is an afebrile disease, there occur occasional periods of fever noticeable to the patients, usually with disturbance of the leprotic lesions and often with the appearance of new ones. Leprosy treatments are apt to induce such reactions. They occur more frequently in treated than in untreated cases, and are often atypical in their manifestations. In the course of the treatment under discussion 75 per cent of the patients had some such reaction.

In most instances the reaction consisted of simple fever without cutaneous manifestations; four had chills, two only once and two repeatedly. The fever in these simple cases without cutaneous manifestations usually lasted but two to five days, though in a few instances it persisted for a week. It was usually remittent, ranging from 37.5° to 38.7° C., and was sometimes accompanied by other disturbances, as headache, weakness, and body pains.

In four cases exacerbations of the leprotic lesions occurred. In these cases fever lasted sometimes as long as three weeks, with daily remissions, the fever ranging from 37.9° to even as high as 39.9° C. In these, more severe reactions the patient seemed decidedly ill.

Another reaction phenomenon occasionally seen, nerve pain, occurred in three of these cases. One of the three patients with repeated reactions in the cutaneous lesions, a case of apparently pure cutaneous type, suffered intense sciatic pains, repeatedly lasting for about four days. Another, a mixed case, with only one skin reaction, also had sciatic pain. The third case with nerve pain, located in both peroneal nerves, had repeated simple febrile reactions without skin manifestation.

When simple fever occurred treatment was usually suspended temporarily, although in some cases it was pushed until other side effects were observed.

After each reaction with exacerbations of the leprotic lesions the patients appeared to have become weakened, but this was not so with those manifesting only simple fever.

SUMMARY AND DISCUSSION

The present work was undertaken to try out, on cases under our care, the tartar emetic treatment of leprosy advocated by Cawston and Wildish. These authors claim to have obtained

remarkable results, having observed rapid relief of paralyses, drying up of ulcers, and improvement of the general condition.

Thirty patients in the General Hospital of Culion Leper Colony were given tartar emetic intravenously, twelve received antimony wine in cough mixture, and ten antimony wine undiluted. Treatment was given for six months. Twelve other patients received a modified Castellani mixture for three months only.

These patients were mostly males, the majority more than 30 years of age, and the average duration of the disease was about eleven years.

By the intravenous method, using a fresh 1 per cent solution of tartar emetic in water, we were able to give only an average dose of 0.0015 gram of tartar emetic per week. Administered orally in the form of vinum antimonii, the highest dose that could be given was 0.252 gram per week. In the Castellani mixture 0.2275 gram weekly was given.

No improvement of the leprosy itself was noticed in any of the groups. On the whole, the general condition was unfavorably affected. Six of those in the intravenous group and one of those taking the Castellani mixture died during the period of observation. In about 25 per cent of the survivors in the intravenous group and 42 per cent in the Castellani group the ulcers were improved. This improvement was noticed mostly in ulcers of nodules of short duration.

The outstanding side effects noticed were, in those receiving tartar emetic intravenously, injury to the kidneys; and, in the Castellani group, simple fever and the reaction often spoken of as "lepra fever."

A case of extensive ulceration, probably tertiary yaws, injected for about two months, showed marked improvement and none of the ill effect on the kidney that was so noticeable in the lepers.

The most striking observation in this work is the low tolerance of our patients to tartar emetic introduced intravenously. If we compare the small dose that we were able to give with the massive doses that can be given with impunity in the treatment of other affections, it becomes evident how greatly below par are the kidneys of advanced cases of leprosy that we treated. This is not surprising if we consider the strain on the kidneys in these advanced cases. To whatever direct injurious action may result from the disease itself, with its long years of slow progress and its occasional more or less

protracted periods of febrile lepra reaction, is added the burden caused by the multiple, usually infected, lepromatous ulcers, that in many cases persist for years; the constipation so prevalent in our cases; and the numerous drugs usually received by these patients, by injection or otherwise. In the majority of advanced cases the vital function of the skin is doubtless more or less handicapped by extensive cutaneous lesions, and by nervous changes and the atrophy so often prominent in this stage of the disease. The diminution or absence of sweat over the affected parts is a classical manifestation of the disease. Furthermore, in a surprising number of cases, the limited effective portions of the skin are affected by yet other, incidental skin diseases. It is therefore not to be wondered at that the kidneys of advanced lepers are usually damaged. We are made more and more to realize that, in the therapy of this disease, the influence of the drug used on the kidneys must be carefully observed.

According to Levy and Dimmitt [7] tartar emetic should always be cautiously used. These authors have found that the total non-protein nitrogen in the blood is increased by the administration of even a small amount of tartar emetic for a comparatively short period of time. Underhill, Pearce, Ringer, and Salant [8] have observed injury to the kidneys of experimental animals produced by small doses of tartrates.

Pulmonary tuberculous lesions in certain of our cases showed rapid progress under the influence of the treatment. We are inclined to believe that it is an indirect effect through lowering of the resistance of an already run-down patient, thus enabling the disease to progress rapidly, rather than a direct influence on the tuberculous process.

The patients who were under the Castellani mixture received only 2 grams of potassium iodide daily. Wayson [9] used as much as from 6.5 to 13 grams of potassium iodide per day in Hawaiian lepers, and observed breaking down of the leprotic nodules into ulcers which healed, leaving little scars, with restoration of sensation. Salivation, nausea, and vomiting took place at one time or another in the majority of our patients.

[7] Levy, M. D., and Dimmitt, P. S., Am. Journ. Trop. Med. 2 (1922) 569.

[8] Cited by Levy and Dimmitt, loc. cit.

[9] Wayson, James T., Arch. Derm. & Syph. (1921) 248–249. Quoted in Trop. Dis. Bull. 18 (1921) 5, 405.

There were naturally some differences in the side effects produced by the oral and the intravenous routes. Abdominal pain was more frequent and of less serious import in the group receiving the drug by mouth. With reference to the kidneys, injury was produced by the intravenous route while no such effects were seen in the other group. Lepra reaction, marked fever usually with cutaneous eruptions, and simple slight fever occurred almost exclusively in the group taking the modified Castellani mixture. It is probable that this reaction is due to the potassium iodide; this drug is well known to have this effect, and it has sometimes been utilized in diagnosis.

As for the effect on the disease, we have not, with the preparations used, been able to confirm the remarkable results of Cawston and Wildish. This is in agreement with the results of Harper [10] of Makogai, who also failed to obtain any improvement in two cases to whom he gave tartar emetic intravenously to the amount of 2.795 and 2.99 grams in thirty-five and thirty-seven injections, respectively.

We regret that we have not been able to use oscol stibium, which Cawston and Wildish used almost exclusively. However, Clark [11] has found that, by pharmacological tests, there is no marked difference between the action of the "colloidal" preparations tested (one of these being oscol stibium) and the same substance in true solution. Furthermore, this worker believes that the results of Wildish and Cawston are very remarkable when a cure was effected by the injection of from 15 to 40 milliliters of the preparation when 40 milliliters of oscol stibium contains only 0.02 gram of antimony. In other diseases 0.3 to 2.4 grams of antimony was found necessary to produce cures. In fact, simple tartar emetic solution would seem to be more advantageous than oscol stibium in some respects, for while the minimal lethal dose of each for mice is the same, 0.015 gram per kilogram of body weight, the minimal curative dose of oscol stibium in experimental trypanosomiasis in mice is more than twice as large as is that of tartar emetic and, consequently, the ratio between the curative and the lethal doses is reduced.

[10] Harper, P., Brit. Med. Journ. No. 3210 2 (1922) 39. Quoted in Journ. Phil. Is. Med. Ass. 2 (1921) 240.

[11] Clark, A. J., Brit. Med. Journ. No. 3242 1 (1923) 273–277.

CONCLUSIONS

1. Antimony in the form of tartar emetic, vinum antimonii, and Castellani's yaws formula, as we have employed it, appears to be of no real therapeutic value as a means of treating leprosy.

2. Tartar emetic appears to improve some of the ulcerations so commonly found in leprosy but, because of its irritating properties and the fact that it promotes wasting, the use of this drug instead of the more-efficient and less-harmful drugs available is not justifiable.

3. These preparations should be used cautiously in lepers, especially those in the more-advanced stages of the disease. The intravenous medication has, in our experience, proved injurious to the kidneys, which in the majority of these cases showed considerable damage. It also accelerates pulmonary tuberculosis. The Castellani formula tends to excite lepra reaction and is irritating to the stomach.

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We are indebted to Dr. H. W. Wade, chief pathologist and acting chief physician, Culion Leper Colony, at whose suggestion this work was initiated, for valuable help given us in the preparation of this paper. We also wish to express our thanks to Dr. C. B. Lara, supervising physician of Clinic 2, for calling our attention to the use of tartar emetic in lepra fever in his clinic and for help in gathering data on the cases so treated.

ELEVENTH CONTRIBUTION TO THE COLEOPTERA FAUNA OF THE PHILIPPINES

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ONE PLATE

The following new species of Philippine Coleoptera are described in this paper:

CERAMBYCIDÆ

Anoplophora asuanga sp. nov.
Anoplophora tianaca sp. nov.
Anoplophora mamaua sp. nov.
Doliops frosti sp. nov.

CURCULIONIDÆ

Eumacrocyrtus canlaoensis gen. et sp. nov.
Metapocyrtus (*Orthocyrtus*) *moorei* sp. nov.
Metapocyrtus (*Orthocyrtus*) *propolitus* sp. nov.
Metapocyrtus (*Metapocyrtus*) *perpulcheroides* sp. nov.
Metapocyrtus (*Metapocyrtus*) *lumutanus* sp. nov.
Metapocyrtus (*Metapocyrtus*) *similis* sp. nov.
Metapocyrtus (*Metapocyrtus*) *annulatus* sp. nov.
Alcides (*Ornatalcides*) *kalinganus* sp. nov.

CERAMBYCIDÆ

Genus **ANOPLOPHORA** Hope

This genus was founded upon the Assam species *Anoplophora stanleyana* Hope.[1] Newman[2] added the Philippine species *Anoplophora lucipor,* which Westwood[3] redescribed and figured as from the "Manillas." The descriptions given by these authors are rather meager, and the Westwood figure seems to be a rather poor representation of the species in question. The following remarks may aid in differentiating this species from the other Philippine representatives of the genus described in following pages.

[1] Proc. Linn. Soc. London 1 (1839) 43; Trans. Linn. Soc. London 18 (1841) 439, pl. 30, fig. 1.
[2] Entomologist 1 (1842) 275.
[3] Cabinet of Oriental Entomology (1848) 60, pl. 29, fig. 7.

Anoplophora lucipor Newm. Plate 1, fig. 3.

Glossy greenish black, the markings very pale orange, which color mostly changes to creamy white. Antennæ, legs, and underside pale grayish tomentose. The tomentose spots on elytra rather variable in size, particularly the bifid sutural spots. Each elytron with six large dorsolateral primary spots and two smaller spots near base at lateral margin. At suture a series of from three to five bifid spots, which are more or less asymmetrical. All over the surface of elytra a very large number of small and very small spots or dots are scattered between the larger spots. This feature is not present in any of the other species. Prothorax dorsally with a bare discal patch, highly polished, reaching from anterior to posterior margin. The lateral tooth-like projections above also bare and shiny.

Length, 32 to 56 millimeters.

LUZON, Bataan Province, Lamao and Limay (*R. J. Alvarez, C. S. Banks, W. Schultze*).

Anoplophora mamaua[4] sp. nov. Plate 1, fig. 6.

Glossy bluish black; head, prothorax, and underside pale ochraceous tomentose, elytra with bright orange yellow spots. Antennæ and legs pale grayish brown tomentose. Head nearly entirely tomentose except a triangular area at vertex, a longitudinal medial groove extending from front to vertex. Prothorax entirely pale ochraceous tomentose except a narrow parallel longitudinal band dorsally extending from anterior to posterior margin; near the latter it is slightly convergent. The lateral tooth only above near tip slightly bare, sparsely tomentose. Scutellum also tomentose. Elytra scatteredly punctate, the punctures coarser in basal third but finer toward apex. Each elytron with a large orange yellow densely tomentose spot dorsally at base, two smaller spots also basally at lateral margin, and four large spots close to lateral margin, the apical one of which is somewhat triangular. At suture three bifid spots, the largest located before the middle, the smallest at about apical fourth. Behind dorsal basal spot usually one or two small spots. Mesosternum and abdominal sternites laterally with small and more densely tomentose orange spots.

Length, 33 millimeters; shoulder width, 10.8.

[4] *Mamau, tianak,* and *asuang* are the names of evil spirits in Tagalog folklore.

MINDORO, Baco River (*my collector*). Type in the collection of the Bureau of Science.

Anoplophora tianaca sp. nov. Plate 1, fig. 8.

Bluish black; head, prothorax, and elytra with white tomentose markings and spots. Head, front to vertex, antennæ, and legs sparsely and finely grayish tomentose. Sides of head with an irregular white tomentose spot, the longitudinal medial groove very prominent, vertex of head with scattered coarse punctures. Prothorax with an irregular white tomentose spot dorsolaterally and another at sides, below the toothlike projection. Elytra in apical third very coarsely and densely punctate, the punctures smaller toward apex. Each elytron with eight rather large white tomentose spots, six of which form an irregular longitudinal row and two are marginal spots in basal half. Of the six spots, three are located dorsally in basal half, the other three are more lateral in apical half. No sutural spots present. Underside grayish tomentose; mesosternum, metasternum, and abdominal sternites, except the last, laterally with a white tomentose spot.

Length, 26 millimeters; shoulder width, 9.

PANAY, Calivo (*my collector*). Type in the collection of the Bureau of Science, Manila.

Anoplophora asuanga sp. nov. Plate 1, fig. 7, ♀.

Bluish black; head, prothorax, and elytra with white tomentose markings and spots. Head, antennæ, legs, and underside finely grayish brown tomentose. Front of head white tomentose which diminishes toward base of antennæ; vertex and sides also white. Prothorax with an irregular white dorsolateral patch and a large patch at sides. Dorsally a longitudinal bare and glossy discal patch. The lateral tooth projections and subbasal area finely grayish tomentose. Elytra with a large number of medium-sized and small white tomentose spots forming irregular longitudinal rows. Each elytron with a dorsolateral row of twelve to fourteen primary spots, which are more or less asymmetrical. Along lateral margin another row of smaller spots also variable in number but usually ten to twelve. At suture another irregular series of small spots. Prosternum, mesosternum, and metasternum white tomentose. Abdominal sternites, except the last, with a white tomentose spot laterally.

Male, length, 31.5 millimeters; shoulder width, 10; antennæ, 46. Female, length, 39.5 millimeters; shoulder width, 13; antennæ, 39.

MINDANAO, Surigao Province, Surigao. BUCAS GRANDE (*my collector*). Type in the collection of the Bureau of Science, Manila.

Doliops frosti sp. nov. Plate 1, fig. 10.

Head, prothorax, and elytra dark greenish bronze with pale green tomentose markings and spots. Head with an oblong tomentose stripe on front to vertex. Antennæ, first joint coppery bronze, third blackish tomentose and sparsely setose, fourth with basal half whitish tomentose. Prothorax longer than broad, minutely scatteredly punctate, with an anterior submarginal groove and a strongly pronounced posterior submarginal groove; the interspace between the latter groove and posterior margin broader than anterior interspace. At apical half a broad irregular pale green tomentose transverse band. Elytra near base coarsely irregularly punctured, the punctuation toward apex sparser and finer. Each elytron with a wedge-shaped tomentose subsutural spot at base. Before the middle a large transverse tomentose patch extending from near suture, slightly divergent to lateral margin. In apical third a narrow transverse band, also extending from near suture to lateral margin. Apical fourth with a broad V-shaped marking. Underside sparsely grayish pubescent. Mesosternum, metasternum, and first abdominal sternite with a large pale green tomentose spot laterally, the following sternites with a small spot, except the last. Legs coppery bronze.

Length, 11.5 millimeters; shoulder width, 4.5.

SAMAR, Catarman (*R. L. Frost*). Type in the collection of the Bureau of Science, Manila.

I name this interesting species in honor of its collector, through whose kindness I received a number of insects from Samar Island.

This species bears a truly remarkable likeness to *Pachyrrhynchus latifasciatus* Waterh. The exact locality of the latter species is not known; but, on account of the great mimicry aspect of the two species involved, it seems very probable that *P. latifasciatus* Waterh. was collected by Cuming in Samar Island.

CURCULIONIDÆ

Genus **EUMACROCYRTUS** novum

Related to *Macrocyrtus* Heller. Rostrum slightly longer than broad. Scape of antenna reaching beyond posterior margin of eye. Prothorax with distinct and sharply defined anterior and posterior submarginal groove and a dimplelike depression dorsolaterally. Elytra dorsally slightly flattened, the greatest width in the middle, lateral margins from the middle rather abruptly and strongly convergent toward apex; apical fourth of elytra extending beyond abdomen, forming a mammilla-shaped projection in both sexes. First and second abdominal sternites in both sexes connate, the following three well segmented.

Type species, *Eumacrocyrtus canlaonensis* sp. nov., from Negros, Philippine Islands.

Eumacrocyrtus canlaonensis sp. nov.

Dark brown, almost black, with inconspicuous pale bluish white scale markings. Rostrum dorsally scatteredly punctured, with an indistinct longitudinal groovelike depression extending to front, where it forms a well-pronounced groove; at base an indistinct transverse depression. Prothorax as long as broad, glossy, finely and scatteredly punctured, a minute hair arising from each puncture, the punctures nearly obsolete in the male. A dimplelike depression dorsolaterally, nearer middle than base. At lateral margins an irregular patch of fine bluish white scales. Elytra finely, scatteredly punctured and sparsely granulate in the male, in the female the punctures much coarser and more irregular. Elytra dorsally in both sexes with very fine and evenly scattered scales. The latter toward and at basal and lateral margins gradually increase in size and density and are most strongly pronounced as an irregular broad stripe along basal and lateral margins. The apical mammillary projection slightly longer in the female, in both sexes beset with rather long scattered setæ arising from the punctures, particularly along the connate suture. Mesosternum slightly, metasternum and first and second abdominal sternites in the middle with a large and prominent patch of dense furlike ochraceous pubescence in both sexes. Legs reddish brown, femora irregularly punctured, sparsely setose. Tibiæ, on the underside with a number of small tubercles, moderately setose.

Length, male, 14.5 to 16 millimeters (without rostrum); width, 5.8 to 6.6.

Length, female, 14 to 15.5 millimeters (without rostrum); width, 6 to 6.8.

NEGROS, Occidental Negros, Canlaon Volcano (*Taylor, Banks, Curran*).

Twenty specimens of this very characteristic species that I have examined show considerable variation in the punctures and sculpture of the elytra. The hind femora are slightly longer in the males than in the females.

Metapocyrtus (Orthocyrtus) propolitus sp. nov. Plate 1, fig. 5, ♀.

Glossy dark brownish black, with a few scattered pale blue or whitish scales at sides of prothorax and elytra. Nearly related to *Metapocyrtus politus* Heller. Rostrum with a broad and strongly pronounced longitudinal groove confluent with a sharply defined transverse groove at base, densely but irregularly punctured, the punctures toward apex small, but very coarse toward base; front scatteredly punctured, the longitudinal groove from rostrum continued but sharply defined, almost reaching vertex. Sides of rostrum with a groovelike depression before eyes, reaching antennal scrobe. Prothorax broader than long, the greatest width slightly before the middle, rather uniformly scatteredly punctured. A sharply defined anterior submarginal groove and a posterior submarginal groove. Lateral margins with a few scattered pale blue or whitish scales. Elytra short ovate, with irregular puncture rows, the punctures coarser than in *M. politus* Heller. In the male the elytra regularly sloping toward apex, at the latter uniformly rounded, as in the above species, but in the female the apex of elytra forming a large and prominent triangular projection. The latter is formed by two apical thornlike terminations of elytra which are firmly united but still show a distinct broad groovelike depression dorsally. Anterior margin of elytra in both sexes slightly raised or swollen, at lateral basal angle a few scattered scales and in the middle along margin another scattered swarm of scales. Near apex some very fine and scattered silky white hair arising from the punctures. Sides of rostrum and head and legs also beset with scattered silky white hair. Mesosternum and metasternum laterally with a cluster of white scales.

Male, length, 12 millimeters (without rostrum); width, 5.5. Female, length, 13.5 millimeters (without rostrum); width, 6.

LUZON, Kalinga Subprovince, Lubuagan (*my collector*); Davangan (*A. W. C. T. Herre*). Types in the collection of the Bureau of Science, Manila.

The female of this species is very strikingly different from any related species of the genus on account of the peculiar apical projection.

Metapocyrtus (Orthocyrtus) moorei sp. nov.

Glossy black, prothorax and elytra with large golden green metallic scale patches. Rostrum densely punctured, the punctures in apical half small, in basal half coarse and irregular. Basal half with a strongly pronounced somewhat rectangular depression bearing mostly a patch of scales. A distinct dorsal cross groove at base separating rostrum from front. The latter sparsely punctured and with a fine longitudinal median groove. Sides of head with a scale spot below eye. Prothorax slightly broader than long, uniformly scatteredly punctured with an anterior submarginal scale stripe, a large irregular scale patch in the middle toward each side, and an oblong patch at each lateral margin. Elytra ovate, with rather irregular rows of fairly coarse punctures. Each elytron of male with two large scale spots at base, three others at the middle of which an oblong marginal spot extends toward apex, and a series of three or four irregular spots at apical third. In female, and sometimes in male, the two basal spots are confluent, forming a broad crossband; the spots at apical third also confluent, forming a large more or less triangular patch, which extends from first row of punctures laterally to margin. Apex of elytra with a few whitish setæ. Metasternum and first abdominal segment laterally with a large scale spot. In male mesosternum and metasternum in the middle with a rather dense patch of fine setæ. Femora in both sexes in apical part with a large patch or swarm of scales. Tibiæ and tarsi strongly setaceous.

Male, length, 12 millimeters (without rostrum); width, 5. Female, length, 14 millimeters (without rostrum); width, 6.5.

MINDANAO, Lanao Province, Dansalan, April 21, 1920 (*A. Moore*). Types, male and female, in the British Museum.

Four specimens of this species were forwarded to me by the British Museum for determination. I take pleasure in naming this species for its collector, Dr. A. Moore.

Metapocyrtus (Metapocyrtus) perpulcheroides sp. nov. Plate 1, fig. 11, ♂.

Black, moderately glossy; prothorax and elytra with metallic coppery or greenish golden scale spots. In general form very similar to *Metapocyrtus pseudomonilifer* Heller. Rostrum strongly rugose, separated from front by a deep and well-pronounced transverse groove. In basal half a triangular depression, with an indistinct longitudinal groove. Lateral margins of the depression forming slightly raised ridges. Front sparsely and scatteredly punctured, with a sharply defined medial groove and a small bifid scale spot. Sides of head below eye also with a small scale spot. Prothorax broader than long, subspherical, finely and scatteredly punctured; in male, prothorax relatively larger than in female. A well-pronounced anterior submarginal groove and posterior submarginal groove. Dorsally a medial longitudinal groove arising behind anterior submarginal groove and terminating before posterior submarginal groove. Dorsolaterally at anterior margin an irregular scale spot, more or less confluent dorsally in the middle and continued as an irregular marginal stripe laterally. At posterior margin toward each side a large roundish scale spot and some scattered scales laterally along margin. Sides with another scale spot above anterior coxæ. Elytra short ovate, very irregularly striate-punctate. Each elytron with three irregular scale spots at base, four or five more or less confluent spots in the middle forming a transverse row, an oblong spot behind the middle at margin, three other spots forming a transverse row at apical fourth, and another spot near apex. Spots uniform metallic coppery or greenish golden. Mesosternum and metasternum laterally with a scale patch. Femora with a scale ring band near apex.

Male, length, 12.5 millimeters (without rostrum); width, 6. Female, length, 11.8 millimeters (without rostrum); width, 6.

LUZON, Kalinga Subprovince, Pinukpuk (*Herre*). Types in the collection of the Bureau of Science, Manila.

This species is remarkable for its extreme likeness to *Pachyrrhynchus perpulcher* Waterh., with which it was collected from presumably the same bushes. The scale markings in this species seem to rub off very readily, since a number of specimens appear uniform black, but upon close examination the markings are distinguishable as dull grayish spots.

Metapocyrtus (Metapocyrtus) lumutanus sp. nov. Plate 1, fig. 9, ♀.

Glossy black, with small pale golden greenish scale spots. Rostrum divergent toward apex, scatteredly punctured, a medial longitudinal groove and pronounced oblong triangular depression in basal half, the lateral margins of which form somewhat raised ridges. Rostrum with a broad transverse groove at base. Front sparsely punctured with a small roundish scale spot, and an indistinct medial groove in the female. Sides of head with a triangular scale spot below eye. Prothorax as long as broad, in the female dorsally sparsely and scatteredly punctate, in the male almost impunctate. Both sexes with an indistinct anterior and a well-pronounced posterior submarginal groove. A roundish spot dorsolaterally at anterior margin, a triangular spot, also dorsolaterally, near posterior margin, and a small roundish scale patch in the middle at each lateral margin. Elytra oblong-ovate, finely and irregularly punctate-striate; each elytron with eleven small roundish spots. Two spots are located near base, one dorsolaterally, the other near anterolateral angle; three other spots form a transverse row near middle; six spots are located at apical half, one of them at margin, one near apex, three at dorsolateral slope, and one subsutural spot at apical fourth. In the female the latter spot is located on a small roundish tubercle which bears a small tuft of short black setæ. Metasternum with a scale patch laterally. Femora with a circumscribing scale band near apex.

Male, length, 9.8 millimeters (without rostrum); width, 4. Female, length, 11.5 millimeters (without rostrum); width, 5.

LUZON, Rizal Province, Mount Lumutan (*my collector*). Types in the collection of the Bureau of Science, Manila.

Metapocyrtus (Metapocyrtus) similis sp. nov. Plate 1, fig. 1.

Head black, prothorax glossy greenish bronze, elytra glossy dark purplish brown with small pale greenish scale spots. In general aspect this species resembles very much *Metapocyrtus lumutanus*. Rostrum minutely and sparsely punctate toward apex, in basal half with a deep and sharply defined longitudinal medial groove. Rostrum obtusely angled at basal junction with front, the medial groove continued on the latter. Prothorax longer than broad, the greatest width before the middle, impunctate. A distinct anterior submarginal groove beset with a fine narrow scale line. Lateral margins in the middle with

a few scales. Elytra very finely and irregularly punctate-striate. Each elytron with twelve small roundish scale spots, two of them near base, five forming a transverse row in the middle, four forming another transverse row at apical third of which the lateral marginal spot is the largest, and one near apex. Metasternum with a scale spot laterally. Legs greenish bronze, with a bluish and purplish sheen.

Female, length, 10 millimeters (without rostrum); width, 4.5.

LUZON, Rizal Province, Mount Lumutan, at about 600 meters (*my collector*). Type in the collection of the Bureau of Science, Manila.

Metapocyrtus (Metapocyrtus) annulatus sp. nov. Plate 1, fig. 4, ♂.

Glossy black, elytra with grayish scale spots. Rostrum slightly divergent toward apex, scatteredly punctured, at base angulately set off from front, basal half with a longitudinal medial groove, which is continued on front, the latter also sparsely and scatteredly punctured. Eyes rather prominently bulging. Prothorax slightly longer than broad, with a narrow anterior and posterior submarginal scale stripe and a roundish spot at lateral margins. Elytra ovate, finely and irregularly punctate-striate. Each elytron with fifteen rather strongly impressed roundish scale spots; one spot at base near margin, four others forming a transverse row in basal fourth the marginal spot of which is very small, three others forming a transverse row in the middle, four large spots forming a transverse row at apical third, an irregular spot near apex, a small subsutural spot behind the middle, and another at apical fourth. Mesosternum and metasternum with a scale patch laterally. Legs relatively long and slender. Tibiæ on underside rather densely setigerous.

Male, length, 9 millimeters (without rostrum); width, 4.

LUZON, Benguet Subprovince, Mount Pulog (*my collector*). Type in the collection of the Bureau of Science, Manila.

The scales on the impressed spots in this species are very small and rudimentary. This specimen was collected together with specimens of *Pachyrrynchus annulatus* Chevr.

Alcides (Ornatalcides) kalinganus sp. nov. Plate 1, fig. 2.

Subcylindrical, glossy metallic coppery, prothorax and elytra with whitish tomentose markings. Rostrum slightly divergent toward apex, apical half finely and regularly punctured dorsally, above antennal base two small callosities or swellings, basal

half irregularly punctured, the punctures coarser at lateral margins. Front with an oblong shallow depression, the latter terminating in a punctiform impression. Vertex of head finely and regularly punctured. Prothorax broader than long, near anterior margin laterally constricted, uniformly and densely punctured, the punctures rather coarse. At posterior margin dorsolaterally an abbreviated narrow whitish tomentose stripe. Elytra very uniformly and finely punctate-striate, the punctures oblong. Each elytron at base with a transverse depression, extending from the knoblike scutellum to humeral angle, basal margin curved and bent upward. At base just behind scutellum an oblong tomentose spot which forms posterolaterally a short oblique spur. Another spot at basal fourth near lateral margin and a slightly curved transverse band behind middle, reaching from suture to eighth puncture row. Prosternum tomentose, mesosternum and metasternum in the middle only. Abdominal sternites, except the last, with a small irregular tomentose patch laterally. The whole underside greenish bronze, densely and irregularly punctured. Apical part of rostrum, antennæ, and tarsi bluish black.

Length, 12 millimeters (without rostrum); width, 5.

LUZON, Kalinga Subprovince, Pinukpuk (*Herre*). Type in the collection of the Bureau of Science, Manila.

SYNONYMICAL NOTES ON PHILIPPINE COLEOPTERA

The cerambycid generic name *Niphonoclea* Aurivillius replaces *Euclea* Newman, *Niphonoclea gloriosa* Schultze (= *N. opulenta* Heller). Heller's footnote [5] referring to *N. pulchella* Schultze [6] is a mistake; furthermore, *N. gloriosa* and *pulchella* Schultze are nearly related but distinct species. *Niphonoclea tagala* subsp. *rufofasciata* Schultze (=var. *tricolor* Heller). *Pachyrrhynchus signaticollis* Schultze (=*P. transversarius* Heller). *Metapocyrtus* (*Orthocyrtus*) *schönherri* Waterh. (= *M. malayanus* Schultze). *Alcides butuanensis* Schultze (= *A. XV-spilotus* Heller).

[5] Tijdschr. v. Ent. 66 (1923) 43.

[6] Deutsche Ent. Zeitschr. (1922) 36, pl. 1, fig. 7.

ILLUSTRATION

[Drawings by W. Schultze.]

PLATE 1

FIG. 1. *Metapocyrtus* (*Metapocyrtus*) *similis* sp. nov., × 2.
2. *Alcides* (*Ornatalcides*) *kalinganus* sp. nov., × 2.
3. *Anoplophora lucipor* Newm., natural size.
4. *Metapocyrtus* (*Metapocyrtus*) *annulatus* sp. nov., male, × 2.
5. *Metapocyrtus* (*Orthocyrtus*) *propolitus* sp. nov., female, × 2.
6. *Anoplophora mamaua* sp. nov., natural size.
7. *Anoplophora asuanga* sp. nov., natural size.
8. *Anoplophora tianaca* sp. nov., natural size.
9. *Metapocyrtus* (*Metapocyrtus*) *lumutanus* sp. nov., female, × 2.
10. *Doliops frosti* sp. nov., × 2.
11. *Metapocyrtus* (*Metapocyrtus*) *perpulcheroides* sp. nov., female, × 2.

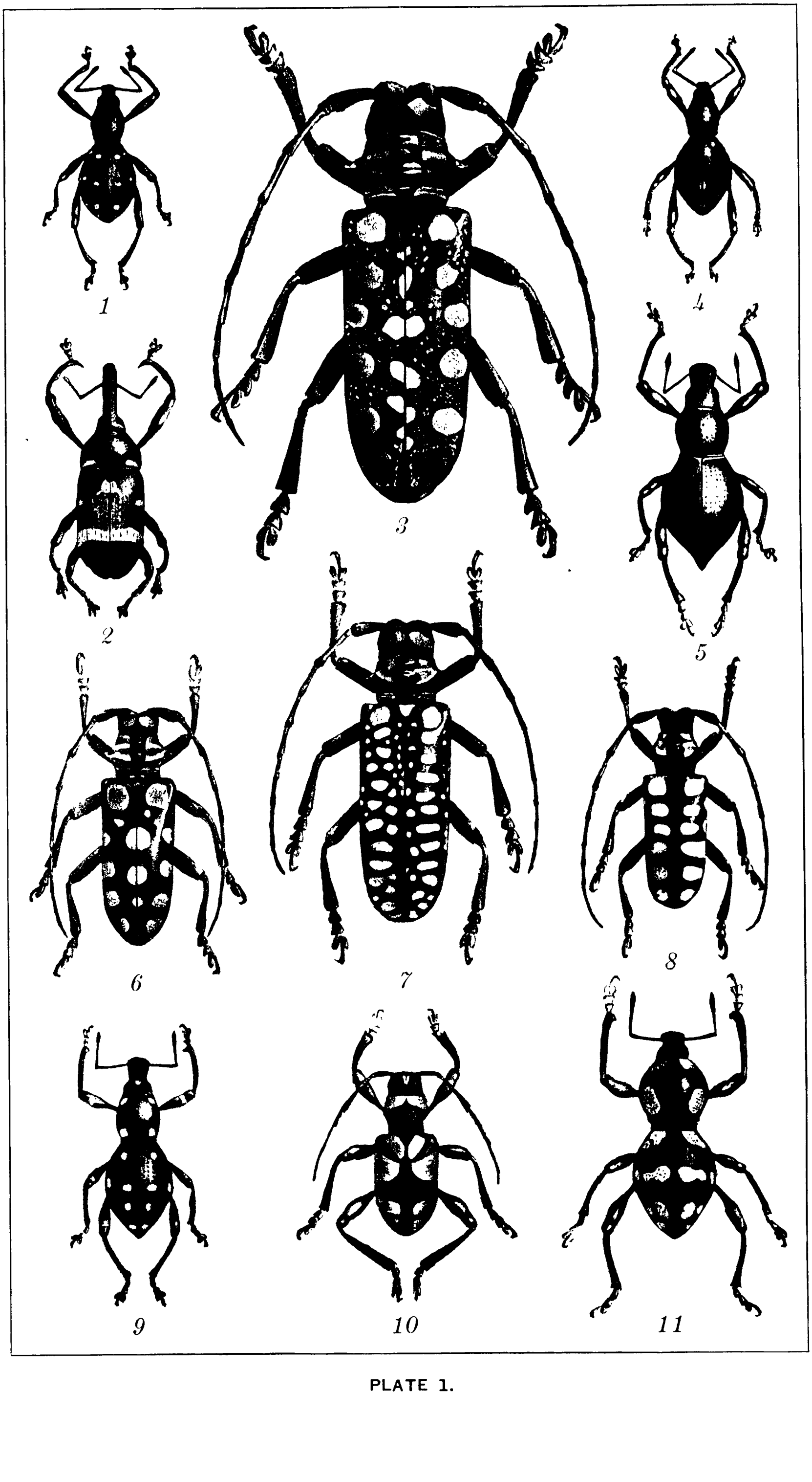

PLATE 1.

A MONOGRAPH OF THE PACHYRRHYNCHID GROUP OF THE BRACHYDERINÆ, CURCULIONIDÆ: PART I

THE GENUS PACHYRRHYNCHUS GERMAR

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NINE PLATES

INTRODUCTION

The Pachyrrhynchides constitute the twelfth group of the second tribe, or subfamily, Brachyderinæ of Lacordaire;[1] they are members of the large family Curculionidæ and represent one of the most highly specialized and remarkable groups of beetles of the Austro-Malayan region. This group of snout beetles has the largest representation in the Philippine Islands and the species number fully one-third of all the curculionids of this region. The peculiar general form of body and the splendidly rich and beautiful scale coloration in manifold designs and markings have attracted the attention of naturalists that have had the opportunity to observe these beetles in their native haunts, as well as of entomologists in general. During my residence of over twenty years in the Philippines and my entomological rambles in various islands of the Archipelago the pachyrrhynchids have always claimed my special attention.

This rather isolated group of beetles offers many interesting problems as well as great difficulties concerning identification due to strong similarities of species in one genus or of species belonging to different genera. Owing to inadequate descriptions, particularly by some of the early writers, it seems advisable to treat the group in monographic form with full and detailed descriptions. The large amount of correctly localized material of this group at my disposal seems to be adequate for this undertaking.

I wish to express here my sincere thanks to all the friends who have collected and contributed material pertaining to this

[1] Hist. Nat. Insectes. Genera Coleopt. 6 (1863) 27.

group, particularly to Mr. R. C. McGregor, Mr. M. H. Curran, Mr. Edward H. Taylor, and Dr. A. W. C. T. Herre.

I am well aware that, in many instances, it is difficult to recognize a certain species even from a good description, particularly in such genera as *Pachyrrhynchus* and *Metapocyrtus.* In order to eliminate the difficulties in this respect and to prevent errors of misinterpretation of known species in the future, I consider it essential to give good illustrations of all species as far as possible. All the original drawings, with the exception of Plate 8,[2] have been made by myself.

This, the first part of my paper, treats of the genus *Pachyrrhynchus,* and it is hoped to deal with the other genera in subsequent parts.

All the Philippine representatives of this group are found in localities which have a rather rich tropical vegetation. Favored localities are rather open, mixed forests with a dense undergrowth along rivers and ravines or on ridges and mountains. Most species are found in such localities on the smaller trees, bushes, shrubs, or ferns. Not a single species is known to feed on any strictly cultivated plant. *Pachyrrhynchus orbifer* Waterh. is found in Luzon (Ilocos Norte and Kalinga Provinces), sometimes in very large numbers, on one of the Euphorbiaceæ, *Jatropha curcas* Linn. (physic nut). This is a naturalized plant in the Philippines, which is found in a semicultivated stage, and is used by Filipinos as fish poison. Whether or not *P. orbifer* actually feeds on this plant I am unable to say. Relatively few species are found in the lowlands; if they do occur there, such localities are mostly spurs or low ridges which are really terminations of some mountain range. By far the larger number of species is found in mountain regions between 500 and 2,000 meters altitude. Because of the large percentage of species found in the central and northern parts of Luzon, it seems probable that the picturesque and little-explored mountainous district between 16° and 18° north latitude was the center of dispersal of the pachyrryhnchids or is the region in which they originated. Details concerning their general distribution are given farther on in this paper. In northern Luzon more than in any other island of the group a greater diversity of genera as

[2] I wish to express again my thanks to Prof. K. M. Heller, of Dresden, who kindly assembled the specimens for Plate 8 and secured the services of Mr. Max Böhme for drawing it. Plates 7, 8, and 9 will be published with the conclusion of this part.

well as species were developed. It is assumed that by an adaptation in conformity to special surroundings and environment their peculiar features of development were brought about; geographic and climatic factors have undoubtedly played the most important parts in bringing about such extraordinary developments. In the pachyrrhynchids the soft wings are absent and the elytra are firmly united at the suture. These characters may have been brought about as the direct results of geologic changes at comparatively very ancient times, due to isolation or island formation. Analogous conditions and similar results are found in the insect fauna of other island regions.[3]

I assume that during a very early period, at a time when the land masses which now form the Malay Archipelago were still connected with each other but already disconnected from Formosa, one or probably several ancestral forms of the pachyrrhynchids were distributed over the regions comprising the Philippines, possibly the Moluccas, and the regions around New Guinea. At a later period, and after the land masses had been transformed into islands, the power of flight in these beetles became of secondary importance, or it may have been a direct handicap on account of peculiar physical conditions, such as torrential rains together with heavy winds and storms in these regions. As the result of a combination of such factors wingless forms slowly developed. Later, as a result of the inability of these beetles to fly, the possibilities of traveling great distances became still more limited, and a relatively large number of species developed in the mountainous regions, where evident upheavals and changes of contour occurred in the past due to extraordinary volcanic and other ordinary physical actions. In the large islands most species are found in very limited areas, such as well-defined mountain ranges, certain valleys, and isolated mountains. Other species are found exclusively on small islands, such as Catanduanes, Polillo, Bucas Grande, and Siargao. A very few species range over a relatively large territory; for example, *Pachyrrhynchus orbifer* Waterh., which is found over the entire northern part of Luzon, but according to each particular locality is modified into hundreds of varieties and local forms. Another example is *P. moniliferus* Germ., which is found in the typical form and several very pronounced varieties in Luzon and has subspecies in Mindoro, Polillo, and the Catanduanes. Instances where a certain species is found in several

[3] Wallace, Island Life (1881) 276.

islands of the group are really rare exceptions. More detailed records of these facts are given under General Distribution.

BIOLOGY OF THE PACHYRRHYNCHIDES

Very little is known concerning the biology of the pachyrrhynchids; I have been able to discover the young stages of only one species, *Pachyrrhynchus confusus*. This species is very common in the swamp regions[4] at the foot of Mount Maquiling in Laguna Province, Luzon, near the town of Los Baños. This fresh-water swamp is an extension of the large lake Laguna de Bay. It is overgrown by a mass of coarse grass, shrubs, and bushes, and also by a heavy growth of a peculiar fern, *Acrostichum aureum* Linn. The water in the swamp varies in depth from a few centimeters to half a meter or more at certain times. *Pachyrrhynchus confusus* feeds on this fern. Adult specimens are common during the entire year and seem to be rather long-lived since at any time some specimens with soft elytra, others with hard elytra of fresh appearance, and still others of old worn appearance are found together climbing about on the fern and on other plants in the swamp. The larvæ were found feeding in the soft parts in the older, lower part of the trunk or caudex of the fern, which consists of alternating soft and very hard tissues. Their burrows are very short. Not more than two larvæ were found in any one plant. The larvæ are oblong and of rather uniform diameter.

The pupa was usually found in a crude pupal chamber near the exterior part of the trunk. In general appearance the pupa is rather elongate. The anterior margin of the clypeus and the sides of the head are beset with a few bristles. The mesothoracic and metathoracic segments dorsad, somewhat laterad, are beset with two thornlike tubercles. The abdominal segments are also beset with a series of fleshy tubercles bearing a few short bristles. The anal segment has, dorsolaterally, a more projecting tubercle and several smaller ones, each bearing a long bristle. The adults feed on the leaves of the fern, starting at the edges, and usually devour an oval piece about 2 centimeters long. *Pachyrrhynchus confusus* has the same habit as its allies; namely, the beetles, in climbing about and being approached, at first try to hide by crawling on the underside of the leaf or on the reverse side of the stem. On being approached very closely they instantly drop to the ground and remain mo-

[4] Schultze, Philip. Journ. Sci. § D 13 (1918) 276, pl. 1, figs. 10, 11, should be corrected to read *P. confusus* Schultze, op. cit. 23 (1923) 78–81.

tionless for some time. In the dense undergrowth it is very difficult to rediscover the beetle, since the coloration of this species, as well as that of most of its allies, blends well with the surrounding underbrush.

In its food habits as described above *Pachyrrhynchus confusus* may represent an exception and, therefore, no definite conclusions should be drawn with reference to other species of pachyrrhynchids and their food plants, since I suspect, from circumstantial evidences, that some species are root feeders. The beetles of this group are found mostly crawling about on the leaves and twigs of plants and their legs are especially adapted for climbing and obtaining a good grip. The appearance of the beetles in walking is spiderlike, particularly so on account of their peculiar markings. The whole structure of the body of all pachyrrhynchids is extremely hard and solid, in fact so solid that one may step on such a beetle lying on the ground in the forest without injuring it. The unusual hardness of the body of these insects seems to be intended as a protection against injury from falls, or from other accidents which may occur during the usual heavy and violent seasonal rains and storms. During such torrential rains many small and swift brooklets are formed, particularly in mountainous districts. Since these beetles are usually exposed and do not seem to hide during rains, they are knocked to the ground or into the water at such times. When this occurs the hard body of the insect with the united and inflated elytra seems to act as a float, since the abdomen only partially fills the strongly convex and connate elytra. In order to inform myself in this respect I performed an experiment by placing four living specimens of *Pachyrrhynchus confusus* and one of *P. moniliferus* in separate glass jars containing water. All of them floated on the surface and it was plainly evident that the specimens were drawing air under the elytra by raising the apical termination of the abdomen above the surface of the water. Up to six hours after being placed in the water all were still alive and floating about. After twelve hours, one specimen of *P. confusus* was still afloat and very lively, another was afloat but dead; still another, which was on the bottom, showed slight signs of life and recovered very soon after being taken out. The other specimens were dead on the bottom. Under natural conditions the time of floating would not need to be anywhere near as long as this because the beetle would surely meet some object to cling to in less time than that utilized in the experiment.

The general color of body and elytra in the majority of pachyrrhynchid species is black; in some cases dark blackish blue, or dark glowing red, dark green, or dark brown. Certain species show very pronounced sculptural characters, such as grooves on the elytra, as in *Pachyrrhynchus pinorum* Pasc.; most other species of this genus have the elytra mostly punctate-striate and the color patterns only somewhat impressed on the surface. In most species of such other genera as *Metapocyrtus, Pseudapocyrtus,* and *Apocyrtus* the sculptural differences are more strongly pronounced, especially on the prothorax. The color patterns of the pachyrrhynchids consist of colored chitinous callosities, scalelike hair, or mainly scales which are mostly roundish or lentil-shaped, varying in size. The colors of the markings are many, although mostly pale green or blue or bright red as in *Pantorhytes;* some are metallic golden green, or with a brilliancy like precious stones, as in *Pachyrrhynchus gemmatus* or *P. taylori.* In most species the color markings decrease in beauty after death due to post-mortem changes. Light pale blue colors often change to pale greenish white. The striking opalescence of the scale spots in certain species mostly disappears after death. Also, the peculiar brilliancy of the scale markings is reduced in intensity after death and in some instances disappears entirely.

The form of the body of the species of the different genera of the pachyrrhynchids is rather variable. The rostrum is as a rule relatively short and broad, the prothorax is subglobular or subcylindrical, and the elytra are mostly ovate. The general forms of body as outlined above apply particularly to the genera *Pachyrrhynchus, Pantorhytes,* and *Sphenomorpha.* In the species of the genus *Eupachyrrhynchus* the elytra are rather short, broad, and somewhat flattened dorsally. In *Macrocyrtus* the elytra are very much oblongish and strongly flattened dorsally; the secondary sexual characters are mostly present at the apical termination of the elytra. In the male this part of the elytra is evenly rounded, in the female the apical ends of the elytra are more or less divergent. The elytra of the species of *Proapocyrtus* are rather short, dorsally flattened, and laterally abruptly declined in an acute angle, while in *Apocrytus* the elytra are more inflated and subspherical. In the species of *Pseudapocyrtus* the elytra are relatively very short, strongly inflated, most nearly subspherical, and at the apical termination laterally depressed, ending in an abrupt projection, particularly in the female. In species of *Nothapocyrtus* the elytra are mostly

ovate, not strongly inflated, and somewhat depressed dorsally. The greatest diversity of body forms, particularly of such parts as the rostrum and the elytra, are found in species of *Metapocyrtus*. In most of the species of that genus secondary sexual characters are very pronouncedly manifest, mainly in the differently shaped elytra, in some species in a truly remarkable degree. In species of *Homalocyrtus* the form of the elytra of the two sexes is also very much differentiated. In the males the elytra are mostly divergent toward the apex, in the female more uniformly oblong-ovate. Some time ago I carried out some comparative studies on the penis structures[5] of a large number of species of different genera of the group. The following were examined:

	Species.
Pachyrrhynchus	27
Metapocyrtus	3
Pantorhytes	1
Pseudapocyrtus	2
Apocyrtus	1
Homalocyrtus	3
Macrocyrtus	2

The studies showed very clearly, with particular reference to species of the genus *Pachyrrhynchus,* that this organ is a hard chitinous tube of variable length and form, according to the species, the color pale translucent brown to dark chestnut brown or black. In general aspect the penis forms, with reference to generic characteristics, exhibit marked differences.

Concerning the value of this organ as a medium for the determination of a species, I consider it an excellent criterion, since I found it to be uniform in shape in as many as ten specimens of a species that I examined in this respect. Furthermore, a rather great diversity of form of this organ is found among the different species of a given genus. In generic differences in the structure of this organ certain species of *Pachyrrhynchus* appear closest in similarity to species of *Pantorhytes* and *Metapocyrtus;* but all three of these genera are in great contrast in this respect to species of the genera *Macrocyrtus, Pseudapocyrtus, Apocyrtus,* and *Homalocyrtus.* In order to demonstrate the specific characteristics of the penis structure and the value of this organ as a medium for identification among different species of the genus *Pachyrrhynchus,* figures of 26 species are given. (Plate 3, figs. 13–38.)

[5] Philip. Journ. Sci. 21 (1922) 592, pls. 3 and 4.

MIMETIC RELATIONS

Another very peculiar and outstanding feature of the Pachyrrhynchides is the remarkable resemblance in color and markings of species found together in the same locality or on the same plants, but belonging to different genera of this group, or to different families of Coleoptera, or to different orders of insects. In most instances the color patterns of the different species occurring together and resembling each other are of course not exactly the same, but the general appearance and behavior of the beetles produce the effect of extreme similarity. Table 1 gives a number of such species which were actually observed occurring together.

I have endeavored to ascertain a reasonable explanation for the value that attaches to the similarity in color patterns of different species of Pachyrrhynchides apparently manifesting certain mimicry relations to each other as demonstrated above. Concerning the question of protective mimicry, we assume that the species serving as model is a more abundant form, qualified and protected by special features and logically older than the other species or counter-likeness—the mimetic or unprotected, more recent, and scarcer form. Referring to the species in the list the outstanding fact is that most of those that exhibit such great resemblance to each other are pachyrrhynchids belonging to different genera of this group. All of them have the same general hardness and in none was I able to detect any special glands or other organs which would serve as a protective device. By actual experience in collecting them I observed that in nearly all cases the species belonging to the genus *Pachyrrhynchus* were commoner than were those belonging to the genera *Metapocyrtus* and *Macrocyrtus*, the last named being much scarcer. So far, I have been able to obtain but little evidence concerning the natural enemies of these beetles, such as birds, etc., although I am inclined to believe that they do have some rather specific natural enemies. Perhaps their extreme hardness and compactness is in itself the protective feature that prevents most birds from eating them.

Frogs and toads are to be considered as general enemies of the Pachyrrhynchides, of other Coleoptera, of all other orders of insects, as well as of spiders, centipedes, and even small crustaceans. In August, during the rainy season of 1923, Mr. Edward H. Taylor collected a number of frogs and toads in and around Baguio, Benguet Province. Through his kindness I was able to examine the stomach contents of twelve large frogs,

TABLE 1.—*Species of Pachyrrhynchus occurring together with other pachyrrhynchids or other Coleoptera of mimetic appearance or vice versa.*

Pachyrrhynchus species.	Occurring with—	Locality.
Pachyrrhynchus venustus Waterh. (= *virgatus* Schultze)	*Metapocyrtus* (*Orthocyrtus*) *schoenherri* Waterh. (= *malayanus* Schultze)	Mindanao, Surigao, Surigao.
Pachyrrhynchus venustus insulanus Schultze	*Metapocyrtus schoenherri atratus* Schultze	Siargao and Bucas Grande Island.
Pachyrrhynchus ardentius Schultze	*Metapocyrtus* (*Orthocyrtus*) *insulanus* Schultze	Siargao Island.
Pachyrrhynchus signatus Schultze	*Doliops siargaoensis* Schultze	Siargao Island.
Pachyrrhynchus speciosus Waterhouse	*Doliops geometrica* Waterh. and *Metapocyrtus* (*Orthocyrtus*) *ornatus* Schultze.	Mindanao, Surigao, Surigao, and Dinagat Island.
Pachyrrhynchus postpubescens Schultze	*Doliops multifasciata* Schultze	Mindanao, Bukidnon, Lindabon.
Pachyrrhynchus jugifer Waterhouse	*Metapocyrtus panayensis* Schultze	Panay, Capiz, Mount Macosolon.
Pachyrrhynchus congestus Pascoe	*Metapocyrtus congestus* Schultze and *Alcides schuetzei* Schultze.	Luzon, Benguet, near rest house, kilometer 30.
Pachyrrhynchus orbifer Waterhouse	*Metapocyrtus orbiferoides* Schultze and *Doliops imitator* Schultze.	Luzon, Ilocos Norte, Mount Nagapatan.
Pachyrrhynchus reticulatus Waterhouse	*Metapocyrtus* (*Orthocyrtus*) *pachyrrhynchoides* Heller and *Doliops pachyrrhynchoides* Heller.	Luzon, Laguna, Paete, and Mount Banahao.
Pachyrrhynchus gloriosus Faust	*Metapocyrtus* (*Orthocyrtus*) *bakeri* Heller	Luzon, Laguna, Paete, and Mount Banahao.
Pachyrrhynchus igorota Schultze	*Macrocyrtus trivittatus* Schultze	Luzon, Benguet, Mount Pulog.
Pachyrrhynchus erosus Schultze	*Metapocyrtus interruptolineatus* Heller	Luzon, Benguet, Atok.
Pachyrrhynchus erichsoni Waterhouse	*Doliops curculionides* Waterhouse	Mindanao, Surigao.
Pachyrrhynchus taylori Schultze	*Macrocyrtus kalinganus* Schultze	Luzon, Kalinga, Balbalan.
Pachyrrhynchus basilanus Heller	*Doliops basilana* Heller	Basilan Island.
Pachyrrhynchus perpulcher Waterhouse	*Metapocyrtus perpulcheroides* Schultze	Luzon, Kalinga, Pinukpuk.
Pachyrrhynchus annulatus Chevrolat	*Metapocyrtus annulatus* Schultze	Luzon, Benguet, Mount Polis.
Pachyrrhynchus samarensis sp. nov.	*Metapocyrtus* (*Sphenomorphoidea*) *laevicollis* Waterhouse.	Samar, Catarman.

three medium-sized frogs, and two toads. The results of my examinations are here reported.

LARGE FROGS, RANA MAGNA STEJNEGER

Specimen 1.—Coleoptera: Two Scarabæidæ, *Catharsius aethiops* Sharp; 1 Melolonthidæ, *Apogonia* sp. ?; 1 Tenebrionidæ, *Uloma* sp. ?; 1 Lucanidæ, *Aegus* sp. ?; other Coleoptera, several fragments. Lepidoptera: Geometridæ, 2 larvæ.

Specimen 2.—Lepidoptera: About 20 caterpillars. One centipede.

Specimen 3.—Coleoptera: One Carabidæ, *Thlibops integricollis* Heller; other Coleoptera, several fragments. One spider.

Specimen 4.—Coleoptera: One Melolonthidæ; fragments of other Coleoptera. Hemiptera: One large Reduviidæ. One Forficulidæ. Two stones.

Specimen 5.—Coleoptera: One Melolonthidæ, *Apogonia ?*. Lepidoptera: Several caterpillars of Noctuidæ. Two medium-sized spiders. One centipede (*Scolopendra ?*). Several large earthworms.

Specimen 6.—Coleoptera: Two Curculionidæ, *Pachyrrhynchus pinorum* Pascoe; 1 *Heteroglyma alata* Heller. One small crab. One stone.

Specimen 7.—Coleoptera: Two Melolonthidæ, *Apogonia* sp.; 1 Curculionidæ, *Macrocyrtus nigrans* Pascoe (nearly perfect). Hemiptera: Several fragments of aquatic species, Nepidæ?.

Specimen 8.—Coleoptera: One Scarabæidæ, *Catharsius aethiops* Sharp; 1 Carabidæ; 2 Curculionidæ, *Macrocyrtus nigrans* Pascoe. Fragments of Locustidæ, Acrididæ, and water Hemiptera.

Specimen 9.—Coleoptera: One Elateridæ; 1 Melolonthidæ, *Apogonia* sp. ?; Cetonidæ, elytra of *Protaetia* sp. Lepidoptera: Fragments of caterpillars. Hymenoptera: One large black Formicidæ.

Specimen 10.—Coleoptera: Four Melolonthidæ, *Apogonia* sp. ?. Fragments of Orthoptera. One small centipede.

Specimen 11.—Coleoptera: Elytra of Cerambycidæ; 1 Chrysomelidæ, *Aulacophora* sp. ?. Orthoptera: Fragments of Phasmidæ.

Specimen 12.—Orthoptera: One Gryllidæ; fragments of Acrididæ.

MEDIUM-SIZED FROGS, RANA LUZONENSIS BOULENGER

Specimen 1.—Coleoptera: Fragments. One large spider.

Specimen 2.—This frog evidently had been feeding near a light. Coleoptera: Six small Carabidæ; fragments of other Coleoptera. One earthworm.

Specimen 3.—Orthoptera: Fragments. Hymenoptera: Several medium-sized ants.

TOADS, KALOULA RIGIDA TAYLOR

Specimen 1.—Hymenoptera: Formicidæ, about 80 large black ants, *Crematogaster* sp. ?.

Specimen 2.—Coleoptera: Carabidæ, one nearly entire insect and 6 elytra; Chrysomelidæ, fragments; Scarabæidæ, 2 *Onthophagus* sp. ?; 4 Curculionidæ, *Metapocyrtus* sp. ?. Hymenoptera: Formicidæ, about 50 medium-sized ants and fragments. Hemiptera: Fragments of small insects.

As to the marked resemblance among species belonging to different genera of Pachyrrhynchides, I am almost forced to the conclusion that this is due to the existence of similar conditions in respect to food, surroundings, and environment. The unusual hardness of these beetles seems to have developed more as a protection against accidents due to the usual heavy rains and storms in the regions inhabited by them. The superficial resemblance to spiders I consider as rather incidental. Concerning the different species of cerambycids involved in the above questions, all of which belong to the genus *Doliops* and seem to be very rare, the facts again seem rather to substantiate and emphasize the theory that the hardness of the Pachyrrhynchides is a protection against certain enemies and that the color and pattern resemblance in the rare *Doliops* species developed as a protective device. The *Doliops* species, like most cerambycids, are of moderate hardness. It is well known that many species of this family form the food of many birds, such as woodpeckers, etc.; so it would seem that, if a species of cerambycid resembled a species of beetle not suitable for food, the resemblance would be a protection. I may mention that several cerambycids are known from the Philippines aside from those mentioned above, which bear a strong resemblance to certain surroundings, for example, *Xylorrhiza adusta* Wiedem., which resembles bark; others, like *Ephies coccineus* Gahan, which resemble some other beetles, as Lycidæ, the latter known to be obnoxious for some reason or another.

The rather frequent association of beetles of the above-named groups has been so impressive, to myself as well as to others, that in collecting a certain pachyrrhynchid or *Doliops* we suspected the existence near by of one or the other parallel form. In several instances we were rewarded by finding this true.

The cricket *Scepastus pachyrrhynchoides* from Luzon, described by Gerstäcker,[6] which bears such an extraordinary resemblance to a certain *Pachyrrhynchus* species, I should suppose from the description resembles *P. confusus;* I am unable to add anything about this species. I believe it has not been reported or collected since the time of Semper, its discoverer; it appears to be a very rare insect.

I hope to have shown that the status of the questions concerning the mimicry relations of the pachyrrhynchids is still

[6] Stett. Ent. Zeitg. 24 (1863) 408, pl. 1, figs. 3, 3*a*.

problematic, and further research and much more actual observation in the field are required.

GENERAL DISTRIBUTION OF THE PACHYRRHYNCHIDES

The pachyrrhynchids in their geographic distribution contrast greatly to the other curculionids, all other Coleoptera families and, in a general way, also nearly all other insect orders, even mammalians, reptilians, fishes, and plants, in their almost complete alliance with those of the eastern Malaysian and Papuan regions. This is particularly noteworthy and of great significance since the general alliance of the Philippine fauna and flora is rather uniformly mixed; that is, their alliance is with both the western Malaysian and the eastern Malaysian regions.

The pachyrrhynchids are even rather restricted in their general distribution; by far the largest number of representatives are found in the Philippine Islands. I consider it certain that surprisingly large numbers of species of pachyrrhynchids will yet be discovered in the vast unexplored or only superficially known parts of the Philippines, particularly in the following regions: The Batanes and Babuyanes groups of islands between Formosa and Luzon, on all of which only very limited collecting has been done; northern Luzon, in the eastern mountain ranges, near Mount Moises; Mindoro Island; most of the Visayan islands; and central Mindanao.

Actual entomological collecting has been carried on in practically all of the islands comprising the Philippine group. Much more extensive collecting by many different persons has been done in Luzon (with the exception of the areas above indicated) than in any other island.

The distribution of the respective genera and species of the Pachyrrhynchides is as follows:

1. *Pachyrrhynchus* is represented by about 85 species, of which 81 are found exclusively in the Philippines and only 4 outside; namely, 1 in the Riu Kiu Islands, and 3 in the Moluccas (Sangir, Ternate, and Halmahera). By far the larger number of Philippine species is found in Luzon, and on this island the larger number is found in the mountainous districts of the northern half. Of the other Philippine species about 14 are found in Mindanao and the rest are scattered over various islands.

2. *Eupachyrrhynchus* [7] Heller contains only 1 species (*E. su-*

[7] *Eupachyrrhynchus hieroglyphicus* Schultze must be placed in the genus *Macrocyrtus* Heller.

perbus Heller), the exact locality of which is not known, but I suspect it was collected in northern Luzon.

3. *Macrocyrtus* Heller is represented by 12 species, all of which are found in northern Luzon.

4. *Eumacrocyrtus* Schultze, with only 1 species, Negros.

5. *Proapocyrtus,* Schultze, with only 1 species, Panay.

6. *Apocyrtus* Erichson, with 2 species, Luzon.

7. *Pseudapocyrtus* Heller, with 8 species, 6 of which are found in Luzon, the others in neighboring islands.

8. *Nothapocyrtus* Heller, with 7 species, all of which are found in northern Luzon.

9. *Metapocyrtus* Heller contains about 118 (156) species and is found in practically all the islands of the Philippines, but about 40 per cent of the species are found in Luzon.

10. *Homalocyrtus* Heller contains at present 8 species (16, see Table 2) most of which are scattered over the various islands of the Philippines.

11. *Pantorhytes* Faust, with about 20 species, which are found in the New Guinea region.

12. *Sphenomorpha* Behrens contains about 9 species, of which 7 are found in the New Guinea region and 2 only in the Moluccas.

13. *Apocyrtidius* Heller, with 1 species, is found only in Borneo.

In order to demonstrate more clearly the general distribution of genera and species of pachyrrhynchids involved I have prepared Table 2;[8] the particular distribution of species and subspecies of the genus *Pachyrrhynchus* is given in Table 3.

Table 2 shows clearly that the center of dispersal of the pachyrrchynchids is the Philippine Islands, particularly Luzon. Table 3 shows localities of 85 species and 13 subspecies of *Pachyrrhynchus.*

[8] The numbers of species as indicated in Table 2 for the large genus *Metapocyrtus* and the genus *Homalocyrtus* are only tentative or approximate for demonstration purposes. The actually known number of valid species of *Metapocyrtus* at the present time is about 104, for several of which the exact locality is not known. In the collections at my disposal I have about 156 species of *Metapocyrtus* from the Philippines, which fact indicates how necessary a revision of this genus is before any definite conclusions can be reached. The genus *Homalocyrtus* contains at the present time about 8 known species but among my material of this genus I have 16 species from the localities as indicated in Table 2. Therefore, all figures in Table 2 with an x indicate that at least the given number of species is known from that locality, irrespective of whether they have been determined or are new.

TABLE 2.—*Showing the approximate distribution of the pachyrrhynchids (Curculionidæ).*

[An x indicates that at least the given number of species is known from the locality.]

Genus.	Riu Kiu Islands, 1 species.	Philippine Islands, 298 species and subspecies.																							
		Batanes.	Babuyanes.	Luzon.	Polillo.	Catanduanes.	Mindoro.	Ticao.	Romblon.	Sibuyan.	Masbate.	Panay.	Samar.	Biliran.	Leyte.	Negros.	Cebu.	Bohol.	Dinagat.	Siargao.	Bucas.	Mindanao.	Samal.	Basilan.	Palawan.	Busuanga.
Pachyrrhynchus	1	2	2	55	4	4	2					1	7		2			1	1	3	4	14		1		
Eupachyrrhynchus				1																						
Macrocyrtus				12																						
Eumacrocyrtus																1										
Proapocyrtus												1														
Apocyrtus				2																						
Pseudapocyrtus				6	1	1																				
Nothapocyrtus				7																						
Metapocyrtus		2x	3x	63x	7x	3x	6x	1x	2x	2x	2x	9x	3x	4x	3x	5x	2x	2x	1x	5x	4x	24x	1x		1x	1x
Homalocyrtus				3x	1x	1x			1x	1x			1x		2x			1x	1x	1x	1x	2x				
Pantorhytes																										
Sphenomorpha																										
Apocyrtidius																										
Species accredited to locality	1	4	5	149	13	9	8	1	3	3	2	11	11	4	7	6	2	4	3	9	9	40	1	1	1	1

Genus.	Borneo, 1 species.	Moluccas, 5 species.				New Guinea, 27 species.								Total species.	Total subspecies.
		Sangir.	Ternate.	Halmahera.	Batchian.	New Guinea.	Sud East.	Gebe.	Morty.	Fidji.	Woodlark.	Solomon.	New Britania.		
Pachyrrhynchus		1	1	1										85	13
Eupachyrrhynchus														1	
Macrocyrtus														12	
Eumacrocyrtus														1	
Proapocyrtus														1	
Apocyrtus														2	
Pseudapocyrtus														8	
Nothapocyrtus														7	
Metapocyrtus														156	
Homalocyrtus														16	
Pantorhytes						15	1			1	1	1	1	20	
Sphenomorpha				1	1	5		1	1					9	
Apocyrtidius	1													1	
Species accredited to locality	1	1	1	2	1	20	1	1	1	1	1	1	1	319	13

Recapitulation of Table 2.

Philippines, represented by 10 genera containing 298 species and subspecies of which 9 genera are endemic.
Moluccas, represented by 2 genera containing 5 species.
New Guinea, represented by 2 genera containing 27 species.
Riu Kiu Islands, represented by 1 genus containing 1 species.
Borneo, represented by 1 genus containing 1 species; genus endemic.

TABLE 3.—*Distribution of the species and subspecies of the genus Pachyrrhynchus Germar.*

[Species marked x? are placed provisionally in that locality; the exact locality is not known.]

Pachyrrhynchus—		Philippines.																						Moluccas.		
	Riu Kiu Islands.	Batanes.	Babuyanes.	Luzon North.	Luzon South.	Polillo.	Catanduanes.	Mindoro.	Masbate.	Samar.	Leyte.	Panay.	Negros.	Romblon.	Sibuyan.	Cebu.	Bohol.	Dinagat.	Bucas.	Siargao.	Mindanao.	Basilan.	Palawan.	Sangir.	Morotai.	Ternate.
absurdus																			x							
amabilis																					x					
anellifer				x																						
annulatus				x																						
apicatus						x																				
apocyrtoides																					x					
ardentius																				x						
argus				x																						
atrocyaneus																					x					
baluganus					x																					
basilanus																						x				
benguetanus				x																						
bucasanus																			x							
chamissoi																					x					
chlorites			x																							
circulatus							x																			
confusus					x																					
congestus				x																						
subsp. *coerulans*				x																						
subsp. *pavonius*				x																						
subsp. *ocellatus*				x																						
consobrinus				x																						
corpulentus																					x					

croesus																							x		
cumingi																x									
decussatus							x																		
dohrni				x?																					
dubiosus				x																					
elegans																				x?					
eques				x																					
erichsoni																				x					
subsp. *eschscholtzi*					x	x																			
erosus				x																					
forsteni																									x
gemmatus				x																					
subsp. *purpureus*				x																					
gloriosus					x																				
subsp. *abbreviatus*				x																					
halconensis								x																	
helleri					x?																				
igorota				x																					
inclytus				x																					
infernalis	x																								
jugifer											x														
lacunosus				x																					
latifasciatus										x?															
libucanus										x															
loheri					x																				
lorquini					x																				
möllendorffi					x?																				
moniliferus					x																				
subsp. *chevrolati*					x	x	x			x															
subsp. *stellulifer*								x																	
morio				x																					
morotaiensis																								x	
multipunctatus																x									
nobilis				x?																					
ochroplagiatus				x																					

TABLE 3.—*Distribution of the species and subspecies of the genus Pachyrrhynchus Germar*—Continued.

Pachyrrhynchus—	Riu Kiu Islands.	Philippines.																						Moluccas.		
		Batanes.	Babuyanes.	Luzon North.	Luzon South.	Polillo.	Catanduanes.	Mindoro.	Masbate.	Samar.	Leyte.	Panay.	Negros.	Romblon.	Sibuyan.	Cebu.	Bohol.	Dinagat.	Bucas.	Siargao.	Mindanao.	Basilan.	Palawan.	Sangir.	Morotai.	Ternate.
orbifer		x		x																						
subsp. *gemmans*				x																						
subsp. *azureus*				x																						
perpulcher				x																						
phaleratus							x																			
pinorum				x																						
postpubescens																					x					
pseudoproteus					x																					
psittacinus					x																					
psittaculus					x																					
pulchellus				x																						
regius											x															
reticulatus					x																					
subsp. *cruciatus*				x																						
roseomaculatus										x?																
rufopunctatus						x																				
rugicollis					x																					
samarensis										x																
sanchezi				x																						
sarcitis		x																								
schoenherri																					x?					
schuetzei				x																						
semiignitus																					x					
semperi					x?																					
signaticollis																					x					

signatus																			x	x						
smaragdinus					x?																					
speciosus																	x	x	x	x	x					
sphaericollaris				x																						
stellio					x																					
striatus										x?																
sulphureomaculatus																					x					
sumptuosus				x																						
taylori				x																						
subsp. *metallescens*				x																						
tristis				x																						
venustus											x							x			x					
subsp. *insulanus*																			x	x						
viridans			x																							
zebra				x																						

The outstanding features in these tables are that the Pachyrrhynchides at present contain 13 genera with tentatively 332 species, of which the Philippines are credited with 10 genera and 298 species; 9 genera are endemic to the Philippines; and 4 genera are, so far as known, endemic to Luzon. The most noteworthy fact is that the Philippines contain over 89 per cent of the total species known, and that the 8 genera represented in Luzon contain 149 species, or over 44 per cent of the entire pachyrrhynchid group.

SYSTEMATIC CLASSIFICATION AND BIBLIOGRAPHIC NOTES

The first representative of the pachyrrhynchids was made known by Germar [9] in 1824 who established the genus *Pachyrrhynchus* on the species *P. moniliferus*, the specimens of which were collected by Eschscholtz probably on a trip from Manila to the Lake Taal region in Laguna Province, Luzon. In 1834 Erichson [10] founded the genus *Apocyrtus* based on the species *A. inflatus* Erichs. Two other species which the last-named author described at the same time, *A. profanus* and *A. impius* Erichs., were later placed by Heller in the genus *Metapocyrtus*. The Erichson material was collected by Meyen. [11] From 1841 to 1843 Waterhouse [12] made the largest additions of species to both of the above genera, from material collected by Hugh Cuming. [13]

In order to show the possible localities in which Cuming collected his material in the Philippines the following data are quoted: [13]

"Mr. Cuming," observes the author, "the fruits of whose western voyage are so well known, left England on the 26th of February, 1836; he proceeded to the Philippine Islands, by the permission of the Queen Regent of Spain, and aided by powerful recommendations from her government, which opened to him the interior of the islands * * *.

"Mr. Cuming visited the whole group. His longest stay was in the Island of Luzon, fifteen provinces of which were well ransacked by him. In the Islands Mindoro, Negros, Panay, Siquijod [Siquijor], Cebu, Bohol, Camiguing [Camiguin near Mindanao], Mindanao, Leyte, Samar, Capul, Ticao, Masbate, Burias, Temple, Marinduque, Maracavan, and Ramblon [Romblon], he reaped a fine harvest. He left the Philippines in No-

[9] Insectorum species novae aut minus cognitae 1 (1824) 336.

[10] Nova Acta Acad. Caes. Leop.-Carol. Nat. Curiosor. 16 Suppl. 1 (1834) 253.

[11] Reise um die Erde 2 (1835) 192.

[12] Proc. Ent. Soc. London (1841) 18 and 45; Ann. & Mag. Nat. Hist. 8 (1842) 218; 9 (1842) 302; 11 (1843) 247; Trans. Ent. Soc. London I 3 (1841–1843) 310–327.

[13] Ann. & Mag. Nat. Hist. 7 (1841) 226.

vember, 1839, proceeded thence to Singapore and Malacca, and returned to England in June 1840, * * *."

Further references are found on pages 227–233, 335, 506, 543, 560, and 562; and in volume 8, pages 62, 148, 380, 527, 536, and 538.

From the same material Chevrolat [14] described, also in 1841, unfortunately as Behrens correctly remarks, a number of species of the above genera, the greater number of which turned out to be identical with those described by Waterhouse, but the confusion created by Chevrolat due to the rather vague descriptions has not been completely cleared up. Further additions to this group were made in 1845 by Boheman. [15] Aside from the above-mentioned authors the following made further contributions. Eydoux et Souleyet, [16] Guerin-Meneville, [17] Montrouzior,[18] White,[19] Boheman,[20] and Snellen van Vollenhoven.[21] In 1873 Pascoe [22] added some more species from the Philippines as well as from the Moluccas and the New Guinea region; still others were added by Gestro [23] in 1875, Roelof [24] in 1876, Bates [25] in 1877, and Oberthür [26] and Gestro [26] in 1879. Further additions were made by Chevrolat [27] in 1881.

In 1887 Behrens [28] published an excellent analytical revision and gave a very detailed account of the whole group. This author's résumé was also based on rather limited material, although he described in his paper 2 new genera, *Sphenomorpha* Behr. with 3 new species from the New Guinea region and *Cataphractus* Behr. with 1 species from the same region. The last-named genus was eliminated from the pachyrrhynchids by

[14] Revue zoologique (1841) 224–226.

[15] Boheman in Schönherr, Gen. et spec. Curcul. 8 Suppl. (1845) pars 2, 381–398.

[16] Revue Zool. par La Soc. cuvierienne (1840) 266.

[17] Revue Zool. (1841) 216; Mag. de Zool. (1842).

[18] Ann. des sc. phys. et nat. de la Soc. d'Agric. de Lyon, 2 ser. t VII, 1 (1857) 46.

[19] MacGillivray's Narrat. Voy. Rattlesnake, App. 2 (1852) 388.

[20] Vetonsk. Jakttag. K. Svenska Fregatten Eugen. Resa omkr. Jorden 2 (1859) 119.

[21] Tijdschr. voor Entomol. (1864) 168.

[22] Journ. Linn. Soc. 11 (1873) 154.

[23] Ann. Mus. Civ. Genova 7 (1875) 1008.

[24] Bull. Soc. Ent. Belg. 19 (1876) VII.

[25] Trans. Zool. Soc. (1877) 154.

[26] Ann. Mus. Civ. Genova 14 (1879) 562 and 570.

[27] Le Naturaliste (1881) 348, 359, 439.

[28] Stett. Ent. Zeitg. 48 (1887) 211.

Faust [29] and placed with the celeuthetids. Among the material at the disposal of Behrens was that collected by Semper. He considered the peculiar distribution and mimicry of the group at length and made comparisons to certain mimicry analogues among the Lepidoptera of the Amazon River region. After treating the whole group he partially revised and described 7 apparently new species of *Pachyrrhynchus* of a subsection which he designated, in my opinion very inappropriately, as the "Gemmatus-Gruppe." In the redescription of some of the Waterhouse species he created confusion,[30] which it has taken many years to clear up, mainly due to limited material. In 1888 Kraatz [31] described 3 more species of *Pachyrrhynchus*, made some critical remarks on Behrens's work, and placed the species of the so-called "Gemmatus-Gruppe," in a synopsis table. In 1892 Faust [32] erected the genus *Pantorhytes* for several species that had been described as *Pachyrrhynchus* species but which have morphological characters very different from those of the latter genus. As type he designated *P. chrysomelas* Montr. A determination table and synopsis of the genus *Pantorhytes* Faust [33] was given by Heller in 1903 and 1905. In 1908 Heller founded the monotypic genus *Apocyrtidius*,[34] the type being *A. chlorophanus* Heller from Borneo. Finally, in 1912, Heller [35] published his excellent revision of the pachyrrhynchids, particularly those of the Philippine region. For this work the material from the various larger museums of Europe was made available to Professor Heller as well as the material from the Bureau of Science collection. The existing confusion of the group was definitely cleared up and, due to Heller's efforts, the systematic arrangement of the pachyrrhynchids was effected. Heller described in his work 5 new genera, *Eupachyrrhynchus*, *Pseudapocyrtus*, *Macrocyrtus*, *Nothapocyrtus*, and *Metapocyrtus*, and 53 new species, besides several new varieties of Philippine pachyrrhynchids. He divided *Metapocyrtus* into 7 subgenera. Keys are given for all the known genera of the group and for all the Philippine species. Since 1912 about 24 species

[29] Stett. Ent. Zeitg. 58 (1897) 70.

[30] Schultze, Philip. Journ. Sci. 23 (1923) 77.

[31] Deutsche Ent. Zeitschr. (1888) 25.

[32] Stett. Ent. Zeitg. 53 (1892) 193.

[33] Abh. u. Ber. Zool. Mus. Dresden No. 2 (1902–03) 14; Wien. Ent. Zeitg. 24 (1905) 305.

[34] Stett. Ent. Zeitg. (1908) 129.

[35] Philip. Journ. Sci. § D 7 (1912) 293.

and several varieties have been added by Heller,[36] and 56 species and 6 varieties by myself.[37] In 1918 I erected the monotypic genus *Proapocyrtus,* the type of which is *P. insularis* Schultze, and in 1922 I recognized the necessity for the separation of the subgenus *Homalocyrtus* from *Metapocyrtus* Heller, as a well-characterized genus. Recently I described also the monotypic genus *Eumacrocyrtus.*

Key to the genera of Pachyrrhynchides, mainly as given by Heller.

a^1. Rostrum at most with a fine, indistinct, basal cross groove, mostly without the latter, apical half dorsally mostly bulging or swollen.

b^1. Rostrum in apical half dorsally swollen, basal half dorsally broad flattish depressed.

c^1. Scape not reaching to hind margin of eye, elytra ovate.

d^1. Antennal scrobe distinctly defined, groovelike, curved backward and downward. Episternal suture of metathorax grooved the whole length.. **Pachyrrhynchus Germar.**

d^2. Antennal scrobe posteriorly enlarged to a triangular depression, the upper margin of which is directed toward middle of eye, the lower margin toward ventral side of rostrum. Episternal suture of metathorax only anteriorly depressed. **Sphenomorpha Behrens.**

c^2. Antennal scape reaching to hind margin of eye, elytra in both sexes somewhat depressed.................................... **Eupachyrrhynchus Heller.**

b^2. Rostrum in apical half not swollen, without a large dorsal depression, mostly with a medial longitudinal groove.

e^1. Eyes almost hemispherically produced.

f^1. Scape not reaching to hind margin of eye, rostrum slightly longer than broad.. **Pantorhytes Faust.**

f^2. Scape reaching beyond hind margin of eye, prosternum slightly emarginate, elytra spherically inflated, basal margin not ridged. **Apocyrtus Erichson.**

e^2. Eyes slightly bulging, prothorax subcylindrical, elytra dorsally flattened, laterally strongly and abruptly declined in an acute angle .... **Proapocyrtus Schultze.**

g^1. Upper margin of scrobe ridged, rostrum regularly arched crosswise as well as lengthwise, tapering toward apex. **Pseudapocyrtus Heller.**

g^2. Upper margin of scrobe not ridged.

h^1. Hind femora not armed, or only with a short obtuse tubercle near base.

[36] Ent. Mitteil. **1** (1912) 309; Nova Guinea, Zool. **9** (1914) 647; Philip. Journ. Sci. § D **10** (1915) 219; Deutsche Ent. Zeitschr. (1916) 281–289; Philip. Journ. Sci. **19** (1921) 542–548; Tijdschr. v. Ent. (1923) 47; Stett. Ent. Zeitg. (1923) 8.

[37] Philip. Journ. Sci. § D **7** (1912) 250–258; **13** (1918) 276; 371–378; **15** (1919) 549–557; **20** (1920) 199; Deutsche Ent. Zeitschr. (1922) 36–45; Philip. Journ. Sci. **21** (1922) 574–587; **23** (1923) 77–83; antea 599–604.

*i*¹. Rostrum dorsally flat, only with a more or less strongly indicated medial longitudinal groove. Inner edge of hind tibiæ with a number of obtuse toothlike projections; first and second abdominal sternites connate.

*j*¹. Prothorax with dimplelike depressions dorsolaterally, elytra at apex forming a mammillary projection; hind femora, in both sexes, not nearly reaching to apex of elytra .... **Eumacrocyrtus** Schultze.

*j*². Prothorax without dimplelike depressions, elytra not forming a mammillary projection apically.

Macrocyrtus Heller.

*i*². Rostrum with a broad longitudinal depression, hind femora reaching distinctly beyond apex of elytra, hind tibiæ at most with some fine thorns .... **Nothapocyrtus** Heller.

*h*². Hind femora beset with a sharp thorn on underside before apex, fore coxæ touching each other.[38]

*a*². Rostrum with distinct basal cross groove.

*k*¹. Rostrum in apical part transversely humplike swollen, eyes prominently bulging, at upper margin with a groove, scape short, not nearly reaching hind margin of eye .... **Apocyrtidius** Heller.

*k*². Rostrum in apical part not swollen, eyes not prominently bulging, scape at least reaching to hind margin of eye.

Metapocyrtus Heller.

*l*¹. Rostrum as long as broad, squarish or trapezoidal, the lateral margins set off at right angles, dorsally lengthwise arched and separated by a prominent cross groove from curved front.

Subg. **Artapocyrtus** Heller.

*l*². Rostrum longer than broad.

*m*¹. Dorsolateral edge of rostrum acute, at base falling off at right angles.

*n*¹. Rostrum dorsally curved lengthwise, moderately densely punctured, without any trace of longitudinal ridges, the anterior margin of prothorax raised and becoming broader latero-ventrally.

*o*¹. Prothorax punctured, with distinct anterior submarginal groove, prosternum slightly emarginate.

Subg. **Sphenomorphoidea** Heller.

*o*². Prothorax granulate, anterior submarginal groove dorsally entirely obliterated, the anterior margin laterally becoming broader and ventrally distinctly emarginate.

Subg. **Sclerocyrtus** Heller.

[38] The species resembling *Apocyrtus* which by their characters may lead to this place in the key, must, on account of the visible mandibular scar, be placed among the Scythropines; they belong to the genus *Isoptera* Faust, Ent. Zeitg. Stett. (1895) 56, 4.—Translation of Heller's footnote in Philip. Journ. Sci. § D 7 (1912) 302.

n^2. Rostrum dorsally straight, prothorax mostly not granulate, the anterior margin either all around uniformly narrow or growing still narrower or broader toward underside.
Subg. **Orthocyrtus** Heller.

m^2. Dorsolateral edge of rostrum entirely rounded.

p^1. Elytra elliptical or ovate, as a rule with a ridged basal margin, rarely dorsally flattened; if so, then with a ridged basal margin.

q^1. Elytra more or less striate-punctate, never granulate.
Subg. **Metapocyrtus** Heller.

q^2. Elytra more or less densely granulate.
Subg. **Trachycyrtus** Heller.

p^2. Elytra in the male dorsally flattened, the greatest width behind the middle, posterior declivity very abrupt; in the female the latter is more or less oblique; in both sexes mostly a tuft of setæ at sutural beginning of posterior declivity.
Homalocyrtus **Heller.**

Genus PACHYRRHYNCHUS Germar

Pachyrrhynchus GERMAR, Ins. Spec. Nov. (1824) 336.

Type species, *P. moniliferus* Germar from Luzon, Philippine Islands.

Head convex, eyes lateral, moderately bulging. Rostrum short and stout, at most slightly longer than broad, dorsally with an indistinct basal transverse furrow, but mostly without the latter. Basal half with a broad, more or less strongly pronounced squarish or oblong depression. Apical half dorsally more or less transversely swollen. Sides angulate, with the dorsolateral edges more or less pronounced. Antennal scrobes deep, groovelike, sharply defined, curved downward toward underside. Antenna short and robust, scape not reaching to hind edge of eye, funicular joints together with club one-fourth to one-third longer than scape. Prothorax slightly variable in length, more or less ovoid-ellipsoid or subspherical, truncate at base and anteriorly. Episternal suture of metasternum grooved the whole length. Elytra short to oblong-ovate.

Range: Riu Kiu Islands, Philippines, and Moluccas.

Heller, in order to facilitate determination of the species of *Pachyrrhynchus*, arranged the species mainly according to their color designs or scale markings, into seven groups. Such an arrangement is in the majority of instances quite satisfactory, but in a number of instances gives a wrong conception, in as much as morphologic-heterogenous species are placed together in the same group. For example in Group I are located *Pachy-*

rrhynchus ochroplagiatus Heller, *P. eques* Heller, *P. morotaiensis* Vollh., *P. forsteni* Vollh., and *P. infernalis* Fairm.

The first two and the last one of the above species are certainly very far apart from each other as well as from the other two species, *P. morotaiensis* and *P. forsteni;* the last two are the only species of Group I which are closely related to each other or homogeneous in their characters. Another example of a heterogeneous conglomeration is found in Group III. In this group the homogeneous species *P. pinorum* Pascoe, *P. tristis* Heller, and *P. lacunosus* Heller are placed together with the rather heterogeneous species *P. perpulcher* Waterh., *P. erichsoni* Waterh., *P. schoenherri* Waterh., *P. venustus* Waterh., and *P. smaragdinus* Behrens.

I am well aware of the difficulties involved in constructing a satisfactory arrangement of the species of *Pachyrrhynchus,* on account of the great diversity of superficially apparently heterogeneous forms; but I deem it preferable to arrange the species in groups according to their morphologic affinities and along lines of natural relations, such groups to be designated in accordance with a typical form of species with which all the other species in a given group are more or less homogeneous.

At the present time it seems premature to assign the different species of *Pachyrrhynchus* to subgenera, since in a number of instances subgeneric divisions would have to be created for certain single species. In as much as many localities are represented by a few specimens of a single species, and as many regions are entirely unrepresented in the collections, it seems advisable to make no subdivision until additional material is obtained rather than to make a large number of subgenera of which many would contain but one species each. Owing to the presence of intergrading characters it does not seem advisable to found subgenera upon single species, since more material would probably relegate some of the subgenera to the scrap heap of discarded synonymy.

GROUP I

The members of this group are typified by the species *Pachyrrhynchus moniliferus* Germ. Small to medium-sized species and rather stout in build. Eyes not especially bulging. Prothorax mostly as long as broad, subglobular, the sides evenly rounded with the greatest width at the middle. Elytra short ovate. General color black, with two exceptions, *P. sphaericollaris* Schultze and *P. rugicollis* Waterh. The following species

are placed in this group: *Pachyrrhynchus orbifer* Waterh., *P. infernalis* Fairm., *P. zebra* Schultze, *P. stellio* Heller, *P. rugicollis* Waterh., *P. sphaericollis* Schultze, *P. jugifer* Waterh., *P. decussatus* Waterh., *P. phaleratus* Waterh., *P. halconensis* Schultze, *P. reticulatus* Waterh., *P. circulatus* Heller. The last two are intermediate species, leading to Group II.

Key to species of Pachyrrhynchus, Group I.

a^1. General color not black.
  b^1. Dark purplish coppery, with metallic luster, no scale markings.
    P. sphaericollaris Schultze.
  b^2. Dark reddish brown, prothorax and elytra with rugosities filled with reddish golden scales .... **P. rugicollis** Waterh.
a^2. General color black.
  c^1. Color uniform; no scale markings present.
    d^1. Elytra rather strongly coriaceous, dull, coarsely punctate-striate.
      P. moniliferus var. **inornatus** Waterh.
    d^2. Elytra finely coriaceous, moderately glossy, finely punctate-striate.
      P. infernalis Fairm.
  c^2. Not uniform; with various scale markings.
    e^1. Elytra with separate or confluent, narrow or broad, entire, circular or reticulated markings.
      f^1. Elytra with separated pale yellow rings.
        P. circulatus Heller.
      f^2. Elytra with confluent, narrow or broad, pale green or yellowish green, rounded or netlike markings.
        g^1. Line markings broad; prothorax with a diamond-shaped inclosed area on disk; elytra with reticulated lines.
          P. reticulatus Waterh.
        g^2. Line markings narrow; prothorax discally with a cross figure; elytra with netlike markings.
          P. reticulatus cruciatus Schultze.
    e^2. Elytra with various markings, in but one instance forming narrow interrupted circular markings.
      h^1. Prothorax and elytra with roundish or elongate rose-colored or golden spots.
        i^1. Elytra with a large sutural spot; all spots rose colored .... **P. roseomaculatus** Waterh.
        i^2. Elytra without a sutural spot; all spots golden.
          P. striatus Waterh.
      h^2. Prothorax and elytra with longitudinal or transverse lines or bands entire or interrupted.
        j^1. Prothorax with both median and dorsolateral longitudinal lines.
          k^1. All lines on elytra very narrow, present in fragmentary traces, transverse line much interrupted, consisting of a row of dots.
            P. stellio Heller.

*k*². Lines on elytra broader, transverse bands not interrupted; size large for the group.

*l*¹. Elytra with a broad irregular transverse band and broad and abbreviated irregular longitudinal stripes............ **P. halconensis** Schultze.

*l*². All lines on elytra much narrower than in *halconensis.*

*m*¹. Elytra with the dorsolateral longitudinal lines interrupted in the middle but continuous on apical half.
P. decussatus Waterh.

*m*². Dorsolateral lines on basal half of elytra discontinuous with that of apical half.
P. phaleratus Waterh.

*j*². Prothorax with either a longitudinal medial line or dorsolateral longitudinal lines.

*n*¹. Prothorax only with dorsolateral longitudinal lines, and a band at anterior and posterior margins... **P. libucanus** sp. nov.

*n*². Prothorax without dorsolateral lines, but a medial line or marking connected with a transverse line or marking before the middle.

*o*¹. Basal half of elytra covered with pink scales except for one large bare circular sutural spot.... **P. jugifer** Waterh.

*o*². Basal half of elytra variously marked, but never with a single circular sutural spot.

*p*¹. Basal half of elytra with from three bare circular areas to one continuous transverse area, scaled areas bluish green, pinkish, and various other colors, not brilliant.
P. orbifer Waterh.

*q*¹. All lines and bands of elytra broken up into fine pale yellow interrupted lines inclosing circular spots.
P. orbifer var. **circulifer** Waterh.

*q*². Elytra with more or less well defined spotlike bare areas; scaled areas brilliant greenish golden or coppery. **P. orbifer gemmans** Waterh.

*q*³. Elytra with transverse bare areas confluent along suture, scaled areas brilliant reddish. **P. orbifer gemmans** var. **ardens** Chevr.

q.⁴ Each elytron with three large well-defined transverse dark blue spots.
P. orbifer azureus Schultze.

*p*². Basal half of elytra with two prominent dorsolateral longitudinal lines.

*r*¹. Longitudinal dorsolateral lines very narrow, not interrupted in the middle; medial transverse line more or less fragmentary.
P. zebra Schultze.

*r*². Longitudinal dorsolateral lines interrupted medially or for the greater part of their length; a sharply defined entire or interrupted medial transverse band present.

*s*¹. Elytra with the longitudinal dorsolateral lines very narrow, more or less interrupted in the middle; medial transverse band narrow, regularly interrupted.
P. moniliferus Germar.

*s*². Larger. Lines on elytra broader, medial transverse line not interrupted. **P. moniliferus chevrolati** Eyd. and Soul.

*s*³. Elytra, medial transverse band very broad or interrupted, forming irregular spots.
P. moniliferus stellulifer Heller.

Pachyrrhynchus orbifer Waterh. Plate 1, fig. 3 (lateral view); Plate 6, figs. 1 to 11.

Pachyrrhynchus orbifer WATERH., Proc. Ent. Soc. London (1841) 20; Ann. & Mag. Nat. Hist. 8 (1841) 220; Trans. Ent. Soc. London I 3 (1843) 323;[39] SCHOENH., Gen. Curc. Suppl. 8 (1845) 386; HELLER, Philip. Journ. Sci. § D 7 (1912) 310.

Pachyrrhynchus fimbriatus CHEVR., Rev. Zool. (1841) 224; SCHOENH., Gen. Curc. Suppl. 8 (1845) 387.

Pachyrrhynchus globulipennis CHEVR., Rev. Zool. (1841) 225; SCHOENH., Gen. Curc. Suppl. 8 (1845) 389.

Pachyrrhynchus pretiosus CHEVR., Rev. Zool. (1841) 225; SCHOENH., Gen. Curc. Suppl. 8 (1845) 388.

Pachyrrhynchus scintillans CHEVR., Rev. Zool. (1841) .225; SCHOENH., Gen. Curc. Suppl. 8 (1845) 389.

[39] Pachyrrhynchus orbifer Waterh.

Niger; thorace in medio fascia transversa, et pone hanc plaga longitudinali a transversa usque ad marginem posticum thoracis excurrente, his e squamis caeruleo-viridibus effectis; elytris squamis caeruleo-viridibus indutis, areis 7-rotundatis denudatis.

Long. corp. 6 lin., lat. 3 lin.

Pachyrrhynchus alboguttatus CHEVR., Rev. Zool. (1841) 226; ERICHS., Wiegm. Arch. 2 (1842) 242; SCHOENH., Gen. Curc. Suppl. 8 (1845) 392.

Pachyrrhynchus fahrei SCHOENH., Gen. Curc. Suppl. 8 (1845) 388.

Pachyrrhynchus inornatus WATERH., Proc. Ent. Soc. London (1841) 20; Ann. & Mag. Nat. Hist. 8 (1841) 219; Trans. Ent. Soc. London I 3 (1843) 326; HELLER, Philip. Journ. Sci. § D 7 (1912) 303.

Pachyrrhynchus ardens CHEVR., Rev. Zool. (1841) 225; SCHOENH., Gen. Curc. Suppl. 8 (1845) 389; L. VON HEYDEN, 42. Ber. Senkenb. Naturf. Ges. (1911) 84, pl. 1, fig. 3; HELLER, Philip. Journ. Sci. § D 7 (1912) 310.

Pachyrrhynchus circulifer CHEVR., Rev. Zool. (1841) 226; SCHOENH., Gen. Curc. Suppl. 8 (1845) 392.

Pachyrrhynchus gemmans CHEVR., Rev. Zool. (1841) 225; ERICHS., Wiegm. Arch. 2 (1844) 285; SCHOENH., Gen. Curc. Suppl. 8 (1845) 388; HELLER, Philip. Journ. Sci. § D 7 (1912) 310.

Var. β SCHOENH., loc. cit.

Var. γ SCHOENH., loc. cit.

Var. δ SCHOENH., loc. cit.

Pachyrrhynchus orbifer subsp. *azureus* SCHULTZE, Philip. Journ. Sci. 21 (1922) 577, pl. 2, fig. 8.

Black; head and prothorax shiny, elytra dull, very finely coriaceous. Very nearly related to *P. moniliferus* Germ. Rostrum in apical half scatteredly punctate, basal half with a rather strongly pronounced dorsal depression and a rather indistinct longitudinal groove in the middle. Front with a somewhat squarish bluish green scale spot, another oblong spot below each eye. Prothorax hardly broader than long, subglobular, very finely scatteredly punctate. In the middle an irregularly broader or narrower scaly crossband which is confluent with a scaly area at each side. From the discal part extending to hind margin a wedge-shaped scale spot. The scaleless parts on prothorax form three smaller or larger areas, one in the anterior and two in the posterior half. Elytra punctate-striate, the punctures more or less strongly pronounced. Elytra beset with bluish green scales with the exception of a cross row of three bare areas at base, the larger one of which is divided by suture; another cross row of three bare areas in apical half of elytra and a small bare roundish area at apex.

These bare or scaleless areas are very variable in size and shape, and may be confluent laterally or longitudinally. In most specimens the bare areas are surrounded by pale greenish scale lines (Plate 6, figs. 2, 3, 4, 7, 8) which coloration contrasts with the other scale coloration of the elytra. Femora with an

oblong scale spot in the middle and another spot near apex. Penis structure, Plate 3, fig. 29.

Male, length, 8.5 to 12.5 millimeters (without rostrum); width, 3.5 to 5.5. Female, length, 8.8 to 12.5 millimeters (without rostrum); width, 4.2 to 6.5.

LUZON, Benguet Subprovince, Bued River Valley; Baguio; Mount Santo Tomas; Mount Mirador; Trinidad; Mountain Trail, Baguio to Bontoc: Kalinga Subprovince, Lubuagan: Ilocos Norte Province, Bangui, Burgos, Mount Nagapatan: Cagayan Province, Sanchez Mira (*Schultze*). Abundant on *Jatropha curcas* Linn.

This species has a relatively wide distribution but only in the mountainous parts of northern Luzon. Very probably some local forms will be found in the small islands north of Luzon. I know of no other species of *Pachyrrhynchus* which exhibits such a great variety of forms as *P. orbifer* in reference to the scale designs or markings and the coloration of same. Waterhouse [40] recognized the very great variability of this species and its close relation to *P. moniliferus* Germ. In this connection attention is called to the following well-founded remarks [41] by this author concerning *P. orbifer:*

> This species I suspect, as well as that described under the name *P. chlorolineatus*, is but a local variety of *P. moniliferus*.

Pachyrrhynchus orbifer Waterh. replaces *P. moniliferus* Germ. in the northern half of Luzon in the mountainous regions. The specific demarcation characters between the two species, as such, are in some forms extremely inconspicuous and slight. But for the sake of easier determination and better recognition of the many local forms and variations of both species it is strongly advisable to retain for *P. orbifer* the specific status. My conclusions in this respect I base on the examination of several thousand specimens of both of these species.

In several instances a certain variation is found only in a relatively small locality, but in other instances a rather large series of intermediate forms among the more strongly pronounced variations were found together in some other localities. It is very easy to select hundreds of variations from a large amount of material of *P. orbifer*, many of which, if seen in single specimens, will convey strongly the idea that they rep-

[40] Trans. Ent. Soc. London I **3** (1843) 324–327.
[41] Ann. & Mag. Nat. Hist. **8** (1841) 220.

resent different species. Both Waterhouse and Chevrolat were misled in this way. Unfortunately, as Behrens [42] rightly says, Chevrolat described part of the material pertaining to this group collected by Cuming at about the same time that Waterhouse did. Several of the species indicated above must be placed as synonyms. In order to recognize some of the more characteristic forms of *P. orbifer* it seems advisable to retain some of the older names for certain varieties as follows:

Pachyrrhynchus orbifer var. inornatus Waterh. Plate 6, fig. 1, ♂.

Uniformly black; elytra dull black, rather strongly coriaceous and regularly punctate-striate.

LUZON, Ilocos Norte Province, Bangui (*Schultze*). CALAYAN, Babuyanes group (*McGregor*).

Pachyrrhynchus orbifer var. circulifer Chevr. Plate 6, fig. 2, ♀.

Black; prothorax and elytra with markings consisting of fine pale green or pink interrupted scale lines. The lines on prothorax form a figure like the letter **T**. On the elytra in basal half the scale lines circumscribe three semicircular areas which are placed in a cross row. Behind the middle another cross row of three areas and a small area at apex. Femora with a scale spot in the middle and another near apex.

LUZON, Ilocos Norte Province, Bangui (*Schultze*).

This variety was described by Chevrolat as *P. circulifer;* Waterhouse also mentioned this form specially, and in some instances he assumed that the specimens were old and rubbed off and resembled *P. reticulatus* Waterh. subsp. *cruciatus* Schultze (Plate 5, fig. 3). I examined a large number of perfectly fresh specimens which also give the appearance of being rubbed off. Such specimens have the above indicated fine scale lines and the whole surface is beset with scattered rudimentary scales, except on the bare semicircular areas (Plate 6, fig. 3, female). In certain specimens this kind of rudimentary scale formation is very faintly indicated, in others it is more pronounced and to such a degree that the bare areas are plainly set off. Such specimens represent intermediate varieties leading up to specimens which have the scale formation fully developed, but in which the variations in coloration again are manifold (Plate 6, figs. 4, 6, 7, 8).

I received numerous examples of these varieties from Bangui, Burgos, and Mount Nagapatan, Ilocos Norte Province, Luzon.

[42] Stett. Ent. Zeitg. 48 (1887) 216.

The general scale coloration in these specimens is either pale or dark violet, pale green or bluish green, or pale reddish brown. In the neighborhood of Baguio, Benguet Subprovince, I collected many specimens which have pale green or light blue scale coloration; also some examples in which the general markings are present in only a fragmentary way, being in some instances reduced to more or less interrupted bands, lines, or spots (Plate 6, figs. 10, 11). Some of the last-mentioned varieties bear a strong resemblance to *P. moniliferus* Germ.

Another rather strongly fixed local race I designate as—

Pachyrrhynchus orbifer subsp. **gemmans** Chevr. Plate 6, fig. 9, ♂.

Black, shiny, the scale markings brilliant golden, coppery red or green, glittering like precious stones. Prothorax with a broad crossband which widens at the sides. Elytra regularly and strongly punctate-striate. The bare areas more or less confluent with each other, forming a crossband, sometimes confluent along suture. Femora with the usual spot at middle and near apex.

Male, length, 10.5 to 13 millimeters (without rostrum); width, 4.5 to 6. Female, length, 11 to 13 millimeters (without rostrum); width, 5 to 6.5.

LUZON, Cagayan Province, Tuao, Rio Chico (*Baker*).

Another rather striking form of *P. orbifer* subsp. *gemmans* Waterh. is—

Pachyrrhynchus orbifer subsp. **gemmans** var. **ardens** Chevr. Plate 6, fig. 5, ♂.

Black, the scale markings of a brilliant pale flesh-colored hue.

LUZON, Cagayan Province, Sanchez Mira (*Schultze*).

Still another rather isolated form is—

Pachyrrhynchus orbifer subsp. **azureus** Schultze. Plate 1, fig. 2 (lateral view); Plate 5, fig. 11.

Black; prothorax and elytra with lapiz lazuli crossbands. Front with an oblong scale spot. Prothorax with a crossband which becomes very broad at sides. A wedge-shaped scale spot extends from discal area to hind margin. Elytra indistinctly punctate-striate. Each elytron with a large crossbandlike scale spot at base, not quite reaching suture, another in the middle, and another in apical third. The last-mentioned spot is connected along margin with the spot in the middle.

Male, length, 12 millimeters (without rostrum); width, 5.6.

LUZON, Benguet Subprovince, Kabayan (*Schultze*).

Pachyrrhynchus infernalis Fairm. Plate 1, fig. 1 (lateral view); Plate 8, fig. 6.

Pachyrrhynchus infernalis FAIRM., Bull. Soc. Ent. France (1897) 70; HELLER, Philip. Journ. Sci § D 7 (1912) 304.

Black; head, prothorax, and legs glossy, elytra rather dull. Very nearly related to *P. orbifer* Waterh. Rostrum in apical half scatteredly punctured. Basal half with a strongly developed depression, the dorsolateral edges of which are swollen. Dorsal depression separated from front by an indistinct cross groove. Prothorax subglobular, slightly broader than long, very fine and regularly scatteredly punctured. Dorsally near posterior margin an indistinct rudimentary longitudinal depression. Elytra short and stout ovate, very finely coriaceous and striate-punctate. The punctures finer and closer than in *P. orbifer* Waterh. Underside and legs uniformly black.

Male, length, 11.5 millimeters (without rostrum); width, 5.8.

LIU CHIU ISLANDS, Yayoyama, Ishigaki-shima.

This species is, as stated above, very closely related to *P. orbifer* Waterh., particularly to the uniformly black form var. *inornatus* Waterh., from northern Luzon and the Babuyan group, which it absolutely resembles superficially. Unfortunately, I have only one specimen of *P. infernalis* before me which precludes definite decision as to whether the slight structural differences between it and *P. orbifer* are constant or not. Another noteworthy fact concerning this species is that it is the most northern representative of all the Pachyrrhynchides. Its peculiar geographic distribution seems to indicate that land connections between the Liu Chiu Islands and the Philippines probably existed in ages past.

Pachyrrhynchus moniliferus Germ. Plate 1, fig. 4, ♀ (lateral view); Plate 5, fig. 12.

Pachyrrhynchus moniliferus GERM., Ins. Spec. Nov. 1 (1824) 336; No. 476, pl. 1, fig. 12, *a*, *b*; SCHOENH.,[43] Gen. Curc. 1 (1833) 513; DEJ., Cat. Col. ed. 2, 247; ed. 3 (1837) 270; SCHOENH., Gen. Curc. 5 (1839) 823; op. cit. 8 (1845) 386; WATERH., Proc. Ent. Soc. London (1841) 20; Ann. Mag. Nat. Hist. 8 (1841) 219; Trans. Ent. Soc. London I 3 (1843) 323.

[43] P. moniliferus.

Ater, subtus viridi maculatus, thoracis cruce, elytrorum linea transversa, maculari, media, linea angulata baseas arcuque apicis viridi-adamantinis.

Pachyrrhynchus monilifer GERM., Gemm. and Harold, Cat. Col. (1871) VIII, 2244; BEHRENS, Stett. Ent. Zeitg. 48 (1887) 212; HELLER, Philip. Journ. Sci. § D 7 (1912) 310; SCHULTZE, Cat. Philip. Col. (1915) 132.
Pachyrrhynchus confinis CHEVR., Rev. Zool. (1841) 226.

Black; prothorax and elytra with fine, mostly interrupted, pale green scale lines. Rostrum in apical half densely punctured, in basal half a shallow, somewhat triangular depression with a faintly indicated longitudinal groove. Front scatteredly punctate, with a small oblong scale spot. Sides of rostrum and head below eye with a patch of small whitish setæ and some scattered scales. Prothorax as long as broad, the greatest width before the middle, finely punctate and glossy. In the middle a mostly interrupted longitudinal line and an interrupted cross line across discal area. Another fine line at lateral margins which is continued more or less fragmentarily along anterior and posterior margins. The lines on prothorax above form a figure like a ✠ or the letter T. Elytra short, stout ovate, black, dull, very finely coriaceous and with rather faint rows of punctures, the latter more pronounced in the male. At base a fine line, which is interrupted at suture, and continued more or less interrupted as submarginal line to near apex, at which place it is joined by a short longitudinal line. A fragmentary short branch of this same longitudinal line is present at base. Across the middle of elytra a fine interrupted cross line confluent with submarginal line. Femora with a dash in the middle and a patch of scales near apex. Plate 3, fig. 28, penis structure.

Male, length, 8 to 12 millimeters (without rostrum); width, 3.5 to 5.5. Female, length, 9 to 12.5 millimeters (without rostrum); width, 4.5 to 6.

LUZON, Rizal Province, Montalban, Taytay, Antipolo, Bosoboso: Laguna Province, Los Baños, Mount Maquiling, Paete: Bataan Province, Limay (*Schultze*).

This species is the type of the genus *Pachyrrhynchus*. The typical specimens of this species were collected by Eschscholtz in the neighborhood of Manila during December, 1817, probably on his trip to Taal Volcano. *Pachyrrhynchus moniliferus* is variable in size, as well as in the line markings and coloration of the latter. The lines on prothorax and elytra may be present as a few dots, or as interrupted or complete lines. The typical form of *P. moniliferus* represents the least strongly

pronounced form in a series of local forms or races, most of which are connected up through intermediate forms.

The general distribution of this species and its local races is mainly between 13° and 15° north latitude, in central and southern Luzon, Polillo, Mindoro, and Catanduanes and reaches in a southeasterly direction to Samar.

Pachyrrhynchus moniliferus subsp. **chevrolati** Eyd. and Soul. Plate 1, fig. 5 (lateral view); Plate 5, fig. 20.

Pachyrrhynchus chevrolati EYD. and SOUL., Rev. Zool. (1839) 266; DESM., Voy. La Bonite 1 (1841) 313, pl. 3, figs. 25–26; HELLER, Philip. Journ. Sci. § D 7 (1912) 309.

Pachyrrhynchus concinnus WATERH., Proc. Ent. Soc. London (1841) 45; Trans. Ent. Soc. London I 3 (1843) 322; HELLER, Abh. Ber. Königl. Zool. Anthr.-Ethnogr. Mus. Dresden 7 (1898–99) 6; Philip. Journ. Sci. § D 7 (1912) 321.

Pachyrrhynchus chlorolineatus WATERH., Proc. Ent. Soc. London (1841) 20; Ann. & Mag. Nat. Hist. I 8 (1841) 219; Trans. Ent. Soc. London I 3 (1843) 323, 325; HELLER, Philip. Journ. Sci. § D 7 (1912) 309.

Var. *jagori* HELLER, Philip. Journ. Sci. § D 7 (1912) 321.

Pachyrrhynchus mandarinus CHEVR., Rev. Zool. (1841) 226; HELLER, op. cit. 310.

Larger than typical *P. moniliferus* Germ., prothorax laterally more rounded, elytra more oblong-ovate. The lines on prothorax and elytra not interrupted and much broader, forming stripes. The coloration of the markings yellowish or greenish golden. Rostrum with an oblong scale spot which reaches above front. Prothorax, the longitudinal line is more wedge-shaped and reaches only to the cross line in the middle. The dorsal longitudinal stripes on elytra in basal half are confluent with the crossband, those in apical half not quite reaching the latter.

Male, length, 11 to 13.5 millimeters (without rostrum); width, 4.8 to 6. Female, length, 13 to 14 millimeters (without rostrum); width, 6 to 6.5.

LUZON, Tayabas Province; Albay Province. POLILLO. CATANDUANES, Virac. SAMAR, Catarman, Borongan (*Schultze*).

In *P. concinnus* Waterh. the rows of punctures on the elytra are more distinct, the longitudinal stripes are broader and somewhat divergent at base. The coloration of the markings is very pale green.

SAMAR, Borongan.

Var. *jagori* Heller has the longitudinal marking on the prothorax strongly pronounced wedge-shaped. On the elytra in the apical half are two small oblong spots.

Pachyrrhynchus moniliferus subsp. **stellulifer** Heller. Plate 5, figs. 14 and 18.

Pachyrrhynchus monilifer var. *stellulifer* HELLER, Philip. Journ. Sci. § D 7 (1912) 322.

Black; head, prothorax, and legs glossy bluish black. Scale markings creamy white, flesh color, or pale greenish. Apical half of rostrum strongly punctate, the depression in basal half more pronounced. Front with a small scale spot. Prothorax more rounded at sides. The scale markings on prothorax and elytra much broader, the crossband on the latter sometimes very broad, or also interrupted, forming a cross row of spots.

Male, length, 12 to 12.5 millimeters (without rostrum); width, 5.5 to 6.2. Female, length, 12 to 12.8 millimeters (without rostrum); width, 5.8 to 6.

MINDORO, Naujan (*Taylor*); Mangaran (*C. M. Weber*); San Jose; Mount Halcon (*Schultze*).

This subspecies represents also a rather well-defined local race of *P. moniliferus*.

Pachyrrhynchus zebra Schultze. Plate 1, fig. 6, ♀ (lateral view); Plate 5, fig. 2, ♀.

Pachyrrhynchus zebra SCHULTZE, Philip. Journ. Sci. § D 12 (1917) 253, pl. 1, fig. 5.

Black, with longitudinal, light bluish or greenish scale stripes. Rostrum with a deep pitlike depression in the middle, which disappears between the eyes. Front with a fine medial groove and an elongated spot not continued on vertex. Prothorax smooth and shiny. A narrow band on fore margin continued laterally to hind margin. A transverse medial band joins the side marginal stripe. From disk of thorax, arising from transverse band, a longitudinal stripe to posterior margin, forming the letter T. Elytra very finely wrinkled like leather with very pronounced longitudinal puncture rows. Each elytron with four longitudinal stripes, which run together at basal margin and in apical triangle. A narrow subsutural stripe in apical half of each elytron not quite reaching apex. The broadest stripes are the one located between the second and third rows of punctures and the lateral marginal stripe, both of which are also broader toward base and toward apical triangle. Underside with a spot on mesosternum and metasternum. First abdominal segment with a large spot on each side. Each femur with a scale spot in the middle and a ringlike spot near apex.

Female, length, 11.5 millimeters (without rostrum); width, 5.5.

LUZON, Benguet Subprovince, Mount Santo Tomas (*Schultze*).

Pachyrrhynchus libucanus sp. nov. Plate 3, fig. 12 (lateral view); Plate 9, fig. 5, ♂.

Black; head, prothorax, and legs glossy, elytra rather dull. Prothorax and elytra with pale greenish golden bands and stripes. Rostrum, basal half dorsally strongly but flattish depressed with a large bifid scale spot and a medial groove, the latter reaching to front. Prothorax with a scale band at anterior and posterior margins, both of which are connected by a lateral marginal longitudinal stripe. Toward each side, dorsolaterally, a longitudinal stripe reaching from base to near anterior margin. Elytra finely coriaceous, coarsely and regularly punctate-striate; in the third interstice a medially interrupted stripe, confluent at base with a lateral marginal stripe, the latter continued to apex and confluent again with the abbreviated stripe of the third interstice. A rather broad transverse band in the middle confluent with the marginal stripes. In apical half in the fifth interstice a small roundish spot and in the seventh interstice an elongate spot. Femora with a small spot near apex.

Male, length, 13 millimeters (without rostrum); width, 6.6.

LIBUCAN ISLAND near Samar (*A. Celestino*).

This species resembles superficially certain forms of *P. moniliferus chevrolati*, but is readily distinguishable from the latter by the peculiarly shaped rostrum and distinctly different markings on prothorax.

Pachyrrhynchus phaleratus Waterh. Plate 2, fig. 30 (lateral view); Plate 5, fig. 19, ♀.

Pachyrrhynchus phaleratus WATERH., Proc. Ent. Soc. London (1841) 19, Ann. & Mag. Nat. Hist. **8** (1841) 218; Trans. Ent. Soc. London I **3** (1843) 320; SCHOENH., Gen. Curc. Suppl. **8** (1845) 385; HELLER, Philip. Journ. Sci. § D **7** (1912) 309.

Black with greenish yellow scale stripes. Rostrum dorsally in the middle with broad strongly pronounced transverse groove and another indistinct groove at base, each groove beset with two small scale spots. Both transversal grooves are connected by a narrow and sharply defined longitudinal medial groove. Sides of rostrum and head with a scale spot. Prothorax as long as broad, dorsally before the middle with a transverse line which branches dorsolaterally, one branch extending to the an-

terior, the other to the posterior margin, being continued as lateral marginal stripes and circumscribing the sides. Another short longitudinal line dorsally in the middle reaching from the transverse line to an interrupted posterior marginal line. Elytra short and broad ovate, dull black, very finely coriaceous. A narrow stripe at base is continued as marginal stripe to apex; in the middle a transverse line confluent with marginal stripe. Each elytron in basal half dorsolaterally with a short longitudinal stripe reaching from base to near the transverse line, rarely joining the latter. Apical half with a sutural stripe confluent with marginal stripe at apex, and a longitudinal stripe, which is located more laterally than the one in basal half, from the transverse line to marginal stripe. Shortly before the junction this longitudinal stripe sends off a short branch. Prosternum with an anterior and a posterior marginal line, mesosternum with a transverse scale band, metasternum and first abdominal sternite with a spot laterally. Femora with a circular scale band near apex. Penis structure, Plate 3, fig. 24.

Male, length, 12.7 millimeters (without rostrum); width, 5.8. Female, length, 15.5 millimeters (without rostrum); width, 8.

CATANDUANES, Virac (*Schultze*).

In the basal half of each elytron, in the male, sometimes a rudimentary second longitudinal stripe is present, being in line with the stripe of the apical half. This species is readily distinguished from related species by the peculiar sculpture of the rostrum.

Pachyrrhynchus decussatus Waterh. Plate 1, fig. 25 (lateral view); Plate 4, fig. 3.

Pachyrrhynchus decussatus WATERH., Proc. Ent. Soc. London (1841) 19; Ann. & Mag. Nat. Hist. 8 (1841) 218; Trans. Ent. Soc. London I 3 (1843) 321; SCHOENH., Gen. Curc. Suppl. 8 (1845) 385; HELLER, Philip. Journ. Sci. § D 7 (1912) 309, pl. 1, fig. 14.

Black, with greenish yellow scale stripes. Rostrum dorsally in the middle with a strongly pronounced cross groove beset with scales; from the cross groove extending to the front a longitudinal depression beset with an elongate scale spot. Sides of rostrum and head also with a scale spot. Prothorax as long as broad with a more or less interrupted transverse scale stripe before the middle confluent with a longitudinal stripe at the lateral margins. Three other longitudinal stripes, one dorsally in the middle and one toward each side, dorsolaterally, extend from the transverse stripe to base. Another scale stripe, dor-

sally interrupted, at anterior margin. Elytra short ovate, finely coriaceous and very indistinctly striate-punctate. A transverse stripe at base continued as marginal stripe to apex. In the middle an irregular crossband confluent with the marginal stripes. Dorsolaterally a longitudinal stripe, interrupted behind the crossband, extending from base to near apex, where it becomes confluent with the marginal stripe. In the basal half laterally another longitudinal stripe reaching only to the transverse stripe, the latter at the junction mostly spotlike expanded. The dorsolateral stripe in apical fourth with a short, forward-curved branch. Prosternum and mesosternum closely beset with scales, metasternum and first abdominal sternite with a large scale spot laterally. Femora with a broad circular scale band near apex, anterior femora in addition with an oblong scale patch above. Penis structure, Plate 3, fig. 23.

Male, length, 14 millimeters (without rostrum); width, 6. Female, length, 14.5 millimeters (without rostrum); width, 6.5.

CATANDUANES, Virac (*Schultze*).

This species is closely related to *P. phaleratus* Waterh. The scale markings are somewhat variable. One specimen which I received from Dr. Dexter Allen, from the above locality, has a fine interrupted sutural scale line in apical half; in another specimen a small oblong submarginal spot is located in apical third.

Pachyrrhynchus stellio Heller. Plate 1, fig. 24 (lateral view); Plate 5, fig. 15, ♀.

Pachyrrhynchus stellio HELLER, Philip. Journ. Sci. § D 7 (1912) 320.

Black; prothorax and elytra with pale green scale lines. Related to *P. moniliferus* Germ., but larger and slenderer in form. Rostrum and lines on prothorax very similar to those of *P. phaleratus* Waterh. Rostrum with a rather shallow and flat depression in basal half and a broad transverse scale spot in the middle. Another spot below eye. Prothorax longer than broad, bluish black, glossy, very finely punctate. In basal half of prothorax a combination of lines forming the figure T; the cross line of the latter branches laterally, forward and backward, and circumscribes each side. Elytra finely coriaceous and without any puncture rows. The line markings almost identical with those in *P. moniliferus* Germ., an interrupted cross line in the middle, furthermore each elytron with a short fragmentary longitudinal line at base and apex and a marginal line in apical half.

Male, length, 14 millimeters (without rostrum); width, 6.
Female, length, 13.5 millimeters (without rostrum); width, 6.5.

LUZON, Bataan Province, Lamao, Mount Mariveles (*Schultze*).

Pachyrrhynchus striatus Waterh.

Pachyrrhynchus striatus WATERH., Proc. Ent. Soc. London (1841) 19; Ann. & Mag. Nat. Hist. 8 (1841) 219; Trans. Ent. Soc. London I 3 (1843) 317; SCHOENH., Gen. Curc. Suppl. 8 (1845) 384; HELLER, Philip. Journ. Sci. § D 7 (1912) 308.

Black; prothorax and elytra with golden scale spots. Very closely related to *P. roseomaculatus* Waterh. in general body form as well as in the position of the spots. Front with a scale spot, prothorax with a scale spot dorsolaterally in the middle, both of which are connected discally by a transverse interrupted scale line. Dorsally at base another triangular spot. Elytra strongly striate-punctate, each elytron with six scale spots, of which one, which takes the place of the heart-shaped sutural spot of *roseomaculatus*, is a transverse spot located more dorsolaterally.

Length, 12 millimeters; width, 5.

Philippines, exact locality unknown.

Waterhouse, in his original description,[44] mentions the possibility that *P. striatus* is only a variation of *P. roseomaculatus*.

[44] Trans. Ent. Soc. London I 3 (1843) 317.

Sp. 12. Pachyrrhynchus striatus, Waterh.

Ater; elytris profundè punctatato-striatis; capite maculâ inter oculos; thorace suprà trimaculato; elytris duodecim-maculatis; maculis aureis; illis elytrorum ad basin quatuor, et ad apicem quatuor elongatis, ad medium quatuor, scilicet duabus externis rotundatis, et duabus dorsalibus transversis.

Long. corp. 6 lin., lat. 2 $\frac{2}{3}$ lin.

This species is rather smaller than *P. moniliferus*, and of a narrower form. It is most nearly related to *P. roseo-maculatus*, and very nearly resembles that insect in its markings, but here they are of a golden hue, and instead of the cordiform spot on the suture there are two transverse spots, one on each side, at a short distance from the suture. The elytra are deeply punctate-striated. On the upper surface of the thorax are three spots, one behind, which is triangular, and one on each side; these last are joined by a narrow subinterrupted transverse line. It is possible this may only be a variety of the *roseo-maculatus;* but the difference in sculpture and size, as well as there being two transverse spots distant from the suture in lieu of the cordiform spot on the suture, caused me to separate it. In the present group, however, I have found considerable difference in the sculpturing of specimens of the same species, and the markings in some are subject to extraordinary variations; that is, if I am right in supposing all those insects as varieties of *P. orbifer* which I have given as such.

Since I know *P. striatus* Waterh. only from the description, I am unable to decide this point.

Pachyrrhynchus roseomaculatus Waterh. Plate 1, fig. 30 (lateral view); Plate 9, fig. 1.

Pachyrrhynchus roseomaculatus WATERH., Proc. Ent. Soc. London (1841) 19; Trans. Ent. Soc. London I 3 (1843) 318; SCHOENH., Gen. Curc. Suppl. 8 (1845) 384; HELLER, Philip. Journ. Sci. § D 7 (1912) 308.

Black, moderately shiny, with pink scale spots. Rostrum in basal half with a moderately pronounced triangular depression. Head scatteredly punctured, with a large oval scale spot on front and another at sides of head. Prothorax as long as broad, finely and scatteredly punctured, a small roundish scale spot in the middle toward each side, a large spot dorsally at base and a longitudinal patch at each lateral margin. Elytra with regular and well-pronounced rows of punctures and eleven large pink scale spots as follows: A sutural bifid spot in the middle, each elytron with two oblong-oval spots at base, a large roundish spot laterad in the middle, and two very large oblong-oval spots in apical third, one of the latter being located at the outer margin. Underside of mesothorax, metathorax, and first abdominal sternite with a spot laterally. Femora with a spot on underside near apex.

Male, length, 12.7 millimeters (without rostrum); width, 5.8.

LUZON (?). The only specimen in my collection I received in exchange, without exact locality.

This somewhat isolated species is easily recognized by the peculiar markings. In general form it resembles *P. rugicollis* Waterh.

Pachyrrhynchus rugicollis Waterh. Plate 3, fig. 3 (lateral view); Plate 5, fig. 16, ♀.

Pachyrrhynchus rugicollis WATERH., Proc. Ent. Soc. London (1841) 20; Ann. & Mag. Nat. Hist. 8 (1841) 220; Trans. Ent. Soc. London I 3 (1843) 323; SCHOENH., Gen. Curc. Suppl. 8 (1845) 386; HELLER, Philip. Journ. Sci. § D 7 (1912) 310.

Var. *crucifer* Heller, loc. cit.

Var. *aurinius* Heller, op. cit. 19 (1921) 544.

Head and prothorax black, elytra dull, dark pitch brown, legs bluish black, glossy. Rostrum in apical half strongly and remotely punctate, basal half with well-pronounced triangular dorsal depression. Front finely punctate with a small oblong scale spot. Prothorax slightly broader than long, with more or less

confluent coarse rugosities beset with reddish golden scales having a luster like mother of pearl. Elytra finely coriaceous, very indistinctly striate-punctate, basal and apical fourths with coarse rugosities beset with scales. Mesosternum and metasternum and first abdominal segment with a scale patch laterally. Femora with a scale spot near apex. Penis structure, Plate 3, fig. 30.

Male, length, 8.5 to 12 millimeters (without rostrum); width, 4.5 to 5.5. Female, length, 12 to 12.5 millimeters (without rostrum); width, 6.2 to 6.6.

LUZON, Zambales Province, Iba: Bataan Province, mountains of Mariveles (*Schultze*).

In the var. *crucifer* Heller, the scaled rugosities on prothorax dorsally are somewhat concentrated so as to form a figure approximately like a ✠. The var. *aurinius* Heller refers to a perfectly fresh specimen in which the scales possess in a marked degree the peculiar color and luster of mother of pearl. This coloration, as well as a certain opalescent sheen of the scale markings of many other species of the genus, mostly disappear owing to post-mortem changes.

Pachyrrhynchus sphaericollaris sp. nov. Plate 3, fig. 7, ♂ (lateral view); Plate 6, fig. 12.

Very glossy, dark purplish coppery, without any scale markings. Apical half of rostrum strongly swollen, basal half flat depressed, with a very shallow triangular depression and a strongly pronounced medial groove reaching to front. A small patch of short creamy white hair at sides of head below eye. Prothorax slightly broader than long, subspherical, glossy and impunctate, except a small depression with a few scattered and rather coarse punctures in the middle at each lateral margin. A well-pronounced anterior submarginal groove. The marginal area set off by the latter slightly swollen. Elytra very short ovate, dorsally and laterally strongly and uniformly inflated, with almost obsolete rows of punctures dorsolaterally. A well-pronounced submarginal puncture row from middle to apex, the punctures getting coarser near apex. Near the latter two other abbreviated coarse puncture rows also strongly pronounced, forming groovelike impressions, the interstices forming swollen ridges. Underside and tarsi bluish black.

Male, length, 13.5 millimeters (without rostrum); width, 6.5.

LUZON, Kalinga Subprovince, Pinukpuk (*Herre*).

This remarkable species I place for the present in the *P. moniliferus* group. It is easily recognized by the very distinctly subspheric prothorax, very short ovate elytra, and peculiar coloration. The legs, particularly the tibiæ, are also relatively longer than in any other species of this group but not so slender as in species belonging to the *P. anellifer* group.

Pachyrrhynchus halconensis Schultze. Plate 2, fig. 10 (lateral view); Plate 9, fig. 9, ♀.

Pachyrrhynchus halconensis SCHULTZE, Philip. Journ. Sci. 21 (1922) 577, pl. 2, fig. 3.

Black; moderately glossy, with metallic pale green (male) or coppery micaceous (female) scale markings. Related to *P. phaleratus* Waterh. Rostrum toward apex strongly divergent, in apical half scatteredly punctured, in basal half with a strongly pronounced triangular depression beset with a large scale spot. Front with a triangular spot and sides of head with another spot. Prothorax a little broader than long, very minutely and scatteredly punctured. A crossband, which is sometimes interrupted before the middle, branches laterally, one branch running obliquely toward the anterior and the other toward the posterior margin, both are continued as a lateral marginal stripe and circumscribe the sides. Dorsally in the middle at hind margin a large oblong triangular spot. Elytra in the male oblong, in the female short ovate, the surface very finely coriaceous with very faint traces of puncture rows. A broad irregular crossband in the middle, dorsally in basal half an abbreviated stripe which is continued as a broad basal and marginal stripe to apex. At the latter place it is expanded as a large patch, especially in the female, from which a narrow longitudinal stripe extends forward to crossband. The female mostly has in apical half of elytra an interrupted subsutural stripe. Underside, mesosternum, metasternum, and first abdominal sternite laterally with a scale spot. Femora with a ring spot near apex, interrupted above. Penis structure, Plate 3, fig. 25.

Male, length, 13.6 millimeters (without rostrum); width, 6. Female, length, 17 millimeters (without rostrum); width, 7.8.

MINDORO, subranges of Mount Halcon.

This species is variable in respect to the markings. In the male the longitudinal stripe in apical half of each elytron is abbreviated and does not reach to crossband.

Pachyrrhynchus jugifer Waterh. Plate 2, fig. 7 (lateral view); Plate 5, fig. 1, ♀.

Pachyrrhynchus jugifer WATERH., Proc. Ent. Soc. London (1841) 20; Ann. Mag. Nat. Hist. I **8** (1841) 219; Trans. Ent. Soc. London I **3** (1843) 319; SCHOENH., Gen. Curc. Suppl. **8** (1845) 384; HELLER, Philip. Journ. Sci. § D **7** (1912) 310; SCHULTZE, Philip. Journ. Sci. **13** (1918) 374.

Pachyrrhynchus rhodopterus CHEVR., Rev. Zool. (1841) 224; SCHOENH., Gen. Curc. **8** (1845) 384.

Head, prothorax, and legs bluish black with metallic greenish golden scale markings. Elytra black, the larger part of the surface covered by pink scales. Rostrum in basal half with an oblong triangular depression and a longitudinal median groove. Front with an oblong scale spot. Another spot at side of rostrum and head. Prothorax as broad as long, the sides evenly rounded. The side areas beset with a large patch of scales, dorsally connected by an irregular more or less interrupted medial crossband. Prothorax dorsally, aside from the crossband, with a large triangular spot in the middle at base, which extends to former. Thus, three bare areas are set off dorsally, one in apical half and two in basal half. Elytra black, with well-pronounced rows of punctures, the entire surface beset with pink scales with the exception of the following bare spots and markings: A roundish sutural spot near base, and an irregular crossband at middle. Fore margin of band forms a wavy, hind margin an irregular zigzag line, band spotlike expanded at suture and a narrow sutural stripe is formed in some specimens which becomes confluent with a small bare roundish area at apex. All margins of the bare areas are surrounded by a fine line formed of golden metallic scales, which contrast with the pink scale coloration. Femora with a ring spot near apex.

Male, length, 12.5 millimeters (without rostrum); width, 5.5. Female, length, 11.5 millimeters (without rostrum); width, 5.2.

PANAY, Jamindan and Mount Macosolon (*Schultze*).

This species is related to *P. orbifer* Waterh., but seems to be confined to the above-mentioned island.

Pachyrrhynchus reticulatus Waterh. Plate 2, fig. 28, ♀ (lateral view); Plate 5, fig. 6, ♀.

Pachyrrhynchus reticulatus WATERH., Proc. Ent. Soc. London (1841) 20; Ann. & Mag. Nat. Hist. **8** (1841) 219; Trans. Ent. Soc. London I **3** (1843) 322; SCHOENH., Gen. Curc. Suppl. **8** (1845) 386; HEYDEN, Ber. Senkenb. Naturf. Ges. (1911) 84, pl. 1, fig. 4; HELLER, Philip. Journ. Sci. § D **7** (1912) 310, 323.

Black; prothorax and elytra with pale yellowish green scale stripes forming a net or mesh design. Rostrum in basal half with an oblong depression and indistinct medial groove. In the depression an elongate triangular scale spot reaching to front. Sides of rostrum and head with a scale stripe. Prothorax as long as broad, with a scale line along anterior margin and a combination of curved stripes which circumscribe dorsally five bare areas, two at the anterior margin which are more or less confluent, two at the posterior margin, and a small squarish area discally. The lateral margins also circumscribed by stripes. Elytra very regularly striate-punctate. Each elytron divided by diagonal stripes into nine irregular bare areas, and two additional sutural areas at base and behind the middle are common to both elytra. Prosternum with a scale stripe at anterior and posterior margins and in the middle, mesosternum with a crossband and spots laterally, metasternum also with spots laterally, and first abdominal sternite with a broad crossband. The last abdominal sternite very coarsely punctate and scatteredly scaled. Legs black, femora with a scale spot near apex. Penis structure, Plate 3, fig. 32.

Male, length, 12 millimeters (without rostrum); width, 6. Female, length, 14.5 millimeters (without rostrum); width, 7.

LUZON, Laguna Province, Lilio and Paete (*Schultze*).

This species is rather variable; specimens which I consider as typical in accordance with the Waterhouse description, for part of which see footnote,[45] were collected at the aforementioned locality; but among these specimens are some with red or reddish brown femora. Other specimens which I received from Luzon, Camarines Sur Province, Isarog Volcano, differ from the typical form, since the stripe markings are reduced to fine and narrow scale lines, the color of which is golden green. Still other specimens I designate herewith as—

[45] Sp. 19. Pachyrrhynchus reticulatus, Waterh.

Niger; capite lineis tribus longitudinalibus notate; thorace elytrisque lineis aureo-viridibus vel cupreis areas polygonas circumdantibus reticulate' ornatis; and the following passage from the English description "—The upper surface of the thorax is divided into five areas by coloured lines,—two areas in front, which are more or less confluent, two behind, and a small central one; and on each side of the thorax there is moreover a large inclosed area."

Pachyrrhynchus reticulatus subsp. **cruciatus** subsp. nov. Plate 2, fig. 29 (lateral view); Plate 5, fig. 3.

Black; prothorax and elytra with narrow scale lines. On the dorsal part of prothorax the lines form the figure ✠. Elytra with the lines circumscribing the bare areas not crossing at distinct angles, but forming transverse loops.

LUZON, Tayabas Province, Baler (*Schultze*).

Pachyrrhynchus reticulatus Waterh. seems to be confined to Luzon.

Pachyrrhynchus circulatus Heller. Plate 2, fig. 27 (lateral view); Plate 5, fig. 7, ♀.

Pachyrrhynchus circulatus HELLER, Philip. Journ. Sci. § D 7 (1912) 322, pl. 2, fig. 12; SCHULTZE, op. cit. 21 (1922) 593, pl. 3, fig. 19 (penis structure).

Black, with pale greenish yellow scale line markings. Rostrum in apical half densely punctured, basal half with a rather flat depression. Front with a scale line forming a small rectangle. Prothorax as long as broad, discally with an indistinct medial groove. A scale line forming dorsally a reversed pear-shaped figure and confluent with lines at the lateral margins which form an irregular, distorted ring design. Elytra regularly striate-punctate. Each elytron with five more or less ring-shaped figures, two at base which usually touch each other, two others slightly behind the middle are well separated, and a large ring-shaped figure near apex. The latter is connected by a marginal line with the outer ring in the middle. Underside black, prosternum with a scale line in the middle and at fore and hind margins, mesosternum with a small ring spot laterally connected by a crossband. Metasternum with a spot laterally, first abdominal sternite with a broad crossband, and last sternite with a scale patch laterally. Femora with a scale band interrupted above, near apex. Penis structure, Plate 3, fig. 31.

Male, length, 10.5 millimeters (without rostrum); width, 5. Female, length, 12.5 millimeters (without rostrum); width, 6.

CATANDUANES, Virac (*Anacleto Duyag*).

My collector obtained numerous specimens of this species from the above locality only. The specimens show very little variation. Heller considered this species as closely related to *P. reticulatus* Waterh. which fact seems to be substantiated by

certain similarities in the penis structure. Its relation to some other species and the relation of those species to each other, are well demonstrated on Plate 2, figs. 21 to 29, which shows the following species, together with the localities in which they were found:

Fig. 21. *Pachyrrhynchus absurdus* Schultze, Bucas Grande Island.
22. *Pachyrrhynchus postpubescens* Schultze, Mindanao Province, Bukidnon.
23. *Pachyrrhynchus speciosus* Waterh., Mindanao; Bucas; Siargao; Dinagat.
24. *Pachyrrhynchus samarensis* sp. nov., Samar.
25. *Pachyrrhynchus regius* Schultze, Leyte.
26. *Pachyrrhynchus latifasciatus* Waterh., exact locality unknown.
27. *Pachyrryhynchus circulatus* Heller, Catanduanes.
28. *Pachyrrhynchus reticulatus* Waterh., Luzon, Laguna Province.
29. *Pachyrrhynchus reticulatus* subsp. *cruciatus* subsp. nov., Luzon, Tayabas Province.

All these species show very distinctly their common ancestry; they also show their divergent development, due to long geographic isolation, into well-separated and distinct species.

GROUP II

Group II is typified by *Pachyrrhynchus speciosus* Waterh. Body form mostly very similar to that of the species of the *P. moniliferus* group. General color dark glowing red, coppery, or dark green. Prothorax and elytra very strikingly marked with narrow scale stripes, bands, or ring figures.

Key to the species of Pachyrrhynchus, Group II.

a^1. Prothorax dorsally with two longitudinal scale lines, or an arrow-shaped figure.
  b^1. Prothorax dorsally with two longitudinal scale lines, divergent at base, convergent toward and confluent at anterior margin.
    P. postpubescens Schultze.
  b^2. Prothorax dorsally with scale lines forming a more or less slender arrow-shaped figure.
    c^1. Elytra with narrow or very broad band markings.
      d^1. Elytra with very narrow crossbands.............. P. speciosus Waterh.
      d^2. Elytra with three very broad crossbands, first and third interrupted at suture.. P. samarensis Schultze.
    c^2. Elytra with large irregular ring figures.............. P. regius Schultze.
a^2. Prothorax dorsally with two subparallel transverse scale lines or a transverse band.
  e^1. Prothorax with two subparallel transverse scale lines.
    P. absurdus Schultze.
  e^2. Prothorax with a broad transverse band which is discally narrow and divergent toward the sides........................ P. latifasciatus Waterh.

Pachyrrhynchus speciosus Waterh. Plate 2, fig. 23, ♂ (lateral view); Plate 4, fig. 6.

Pachyrrhynchus speciosus WATERH., Proc. Ent. Soc. London (1841) 19; Ann. & Mag. Nat. Hist. 8 (1841) 218; Trans. Ent. Soc. London I 3 (1843) 314; SCHOENH., Gen. Curc. Suppl. 8 (1845) 383; HELLER, Philip. Journ. Sci. § D 7 (1912) 311.

Pachyrrhynchus absurdus SCHULTZE, Philip. Journ. Sci. 15 (1919) 550, pl. 1, fig. 4 (male); HELLER, Entomol. Mitteil. 10 (1921) 196.

Glossy dark glowing red, or like burnished copper, old specimens almost black, with pale green scale markings. Rostrum in basal half with an oblong shallow depression reaching to front and beset with an elongate scale spot. Sides of head and rostrum with another scale patch. Prothorax slightly longer than broad, very finely punctate. Dorsally in the middle two longitudinal scale stripes, convergent toward and confluent near anterior margin, forming a narrow or broad arrow-shaped figure. The lateral margins circumscribed by a scale band forming a large oval figure. Elytra short ovate, striate-punctate. Each elytron in basal third with a transverse oval figure circumscribed by a narrow scale band reaching from first puncture row to lateral margin. In the middle two narrow parallel transverse bands which are confluent at margin with a marginal stripe, the latter of which circumscribes in apical third a triangular figure. Prosternum, mesosternum, and metasternum beset with scales, first and second abdominal sternites with a large scale patch laterally. Femora with a scale spot near apex.

Male, length, 10.5 millimeters (without rostrum); width, 5.2. Female, length, 12 millimeters (without rostrum); width, 6.

MINDANAO, Surigao Province, Surigao. SIARGAO, BUCAS GRANDE, and DINAGAT (*Schultze*). MINDANAO, Cotabato Province, Saob (*Taylor*). BOHOL, Bilar (*A. Duyag*).

In this species the dorsal arrow-shaped marking on prothorax is variable, in some specimens (from Siargao) rather broad, in others (from Cotabato) very slender, forming almost a straight confluent, anteriorly pointed stripe.

Pachyrrhynchus regius Schultze. Plate 2, fig. 25 (lateral view); Plate 9, fig. 14.

Pachyrrhynchus regius SCHULTZE, Philip. Journ. Sci. 21 (1922) 579, pl. 2, fig. 6, ♀.

Glossy dark glowing red, elytra with large roundish yellowish green annular or ring markings. Rostrum in basal half with a strongly pronounced depression and a fine medial groove, extending to front. The latter with an oblong scale spot. Sides

of rostrum and head with a patch of scales. Prothorax as long as broad, the sides moderately rounded. Dorsally in the middle a longitudinal arrow-shaped marking. Lateral margins with a broad irregular oblong-oval ring marking. Elytra striate-punctate. Each elytron with a very large irregularly roundish ring marking at base, reaching from first puncture row to lateral margin, in the middle a cross row of two other, smaller, and in apical third a larger ring marking. The middle ring marking located near lateral margin is connected with the one in apical third by a broad stripe along margin. The scaled areas on prothorax and elytra are distinctly impressed on the surface. Prosternum, mesosternum, and metasternum beset with scattered scales, first and second abdominal sternites with a scale spot laterally. Femora with a small spot on underside near apex.

Male, length, 12.3 millimeters (without rostrum); width, 5.5. Female, 13 millimeters (without rostrum); width, 6.

LEYTE, mountains near Cabalian (*Gregorio Lopez*).

Pachyrrhynchus postpubescens Schultze. Plate 2, fig. 22, ♂ (lateral view); Plate 4, fig. 4, ♂.

Pachyrrhynchus postpubescens SCHULTZE, Philip. Journ. Sci. 21 (1922) 578.

Glossy dark coppery red, prothorax with pale green longitudinal scale stripes, elytra with markings very similar in design to *P. speciosus* Waterh. Rostrum in basal half with a strongly pronounced dorsal depression, the dorsolateral edges of rostrum distinctly swollen. Front with an oblong-oval scale ring marking, sides of head with a spot below eye. Prothorax almost as broad as long, the greatest width behind middle, dorsally two longitudinal stripes convergent toward anterior margin. Sides with two broad longitudinal stripes which are more or less confluent at anterior and posterior margins. Elytra striate-punctate, the punctures rather large. Each elytron in basal third with a band forming crosswise an irregularly oval figure, reaching from first puncture row to lateral margin. In middle of elytra two crossbands which curve backward on sides and circumscribe a roughly triangular figure in apical third of each elytron. Apical third of elytra scanty pubescent. Prosternum, mesosternum, metasternum, and first and second abdominal sternites more or less densely beset with scattered scales. Femora with a scale spot on underside near apex.

Male, length, 13 millimeters (without rostrum); width, 6. Female, length, 14.5 millimeters (without rostrum); width, 6.6.

MINDANAO, Bukidnon Province, Lindabon (*Schultze*).

Pachyrrhynchus samarensis sp. nov. Plate 2, fig. 24, ♂ (lateral view); Plate 9, fig. 18.

Glossy coppery red with pale green scale markings. Related to *P. speciosus* Waterh. Rostrum in basal half with an oblong triangular depression and an oblong scale spot on front. Another scale spot on sides of head. Prothorax as broad as long, dorsally in the middle with a large oblong scale patch, reaching from anterior to posterior margin. A large scale patch entirely covers sides of prothorax. Elytra with regular and well-pronounced rows of punctures. Each elytron with a large scale patch at base, reaching from first row to lateral margin. In the middle a broad crossband and in apical fourth a large triangular patch which is narrowly connected along lateral margin with crossband. Femora with some scattered scales apically on underside.

Male, length, 10.5 millimeters (without rostrum); width, 5.

SAMAR, Catarman (*R. L. Frost*).

Pachyrrhynchus absurdus Schultze. Plate 2, fig. 21 (lateral view); Plate 4, fig. 5, ♀.

Pachyrrhynchus absurdus SCHULTZE, Philip. Journ. Sci. **15** (1919) 550, pl. 1, figs. 3, 3*a*, ♀.

Dark, glossy, glowing red, with bands of pale green scales. Rostrum sparsely punctured, with a strongly pronounced, oblong depression from the middle extending to front, where it becomes shallow. The depression with an oblong pale green scale spot. Another spot at each side of head. Prothorax slightly broader than long, with an indistinct anterior submarginal groove and a strongly pronounced posterior submarginal groove. Female with a pair of subparallel transverse bands across disk, from one lateral margin to the other. Elytra of female one-half longer than broad, apically terminating in a prolonged thorn, which is slightly bent downward. Elytra punctate-striate. Female with two pairs of subparallel bands across disk from one lateral margin to the other, and at apical third another band forming a triangle. The basal pair of bands interrupted at suture, but confluent along lateral margin. The anterior and posterior bands of second pair curved backward at and near lateral margin; they recurve so as to form the triangular figure

apically. A scale spot on each femur near apex, below. Posterior femora of female not reaching beyond apex of elytra.

Female, length, 15.8 millimeters; width, 6.8.

BUCAS GRANDE (*Schultze*).

Pachyrrhynchus latifasciatus Waterh. Plate 2, fig. 26 (lateral view); Plate 9, fig. 17.

Pachyrrhynchus latifasciatus WATERH., Proc. Ent. Soc. London (1842) 45; Trans. Ent. Soc. London I 3 (1843) 317; SCHOENH., Gen. Curc. Suppl. 8 (1845) 383; HELLER, Philip. Journ. Sci. § D 7 (1912) 311; SCHULTZE, Philip. Journ. Sci. 23 (1923) 78.

Glossy dark green, prothorax and elytra with pale greenish crossbands. Rostrum in apical half strongly bulging, basal half with a rather shallow impression and a longitudinal groove. Prothorax slightly broader than long, subglobular, with a crossband in the middle which is narrow discally, becoming wider toward lateral margins. Elytra with very regular, strongly pronounced rows of punctures and a crossband near base, another slightly broader at middle; both these bands are interrupted at suture and the second is curved on the side of elytra and runs backward along margin. Each elytron in apical third with a large oblong spot parallel to suture and two smaller, more roundish spots laterally.

Male, length, 12.5 millimeters (without rostrum); width, 5.8.

Philippines, exact locality unknown.

The description is taken from a specimen loaned by the British Museum.

Pachyrrhynchus latifasciatus Waterh. represents a somewhat isolated species of the genus, but seems to be most closely related to some of the *P. speciosus* group.

GROUP III

Group III comprises two of the extra-Philippine species, *Pachyrrhynchus morotaiensis* Vollh. and *P. forsteni* Vollh. Both species are quite different from any of the Philippine groups, but come closest in general appearance to some of the *P. moniliferus* group.

Key to the species of Pachyrrhynchus, Group III.

a^1. General color bluish black. Elytra with white scale spots forming cross rows. The spots in the middle row approaching each other very closely, thus forming an interrupted crossband. **P. forsteni** Vollh.

a^2. General color black. Elytra with a cork-colored crossband at base and in the middle .... **P. morotaiensis** Vollh.

Pachyrrhynchus morotaiensis Vollh. Plate 3, fig. 39 (lateral view); Plate 8, fig. 9.

Pachyrrhynchus morotaiensis VOLLH., Tijdschr. v. Ent. 7 (1864) 169; HELLER, Philip. Journ. Sci. § D 7 (1912) 305.

Pachyrrhynchus waterhousei FAUST, Stett. Ent. Zeitg. (1895) 95.

Black glossy; prothorax and elytra with pale cork-colored scale markings. Rostrum in basal half with a shallow depression beset with a large scale spot. Prothorax broader than long with a scale stripe along anterior and posterior margins, both stripes confluent at lateral margin. Elytra oblong-ovate with rudimentary indicated rows of punctures which are somewhat more strongly pronounced near lateral margin and apex. Each elytron with a narrow crossband at about basal fourth, reaching from first puncture row to lateral margin. A second crossband in the middle more or less interrupted at suture. Apical fourth with two lateral scale spots and a more or less interrupted longitudinal stripe in third interstice. Underside, mesosternum, metasternum, and first abdominal sternite with scattered scales and finely whitish setose. Legs sparsely setose.

Male, length, 11 millimeters (without rostrum); width, 4.8.

MOROTAI, Moluccas.

This species is nearly related to *P. forsteni* Vollh.

Pachyrrhynchus forsteni Vollh. Plate 3, fig. 40 (lateral view); Plate 8, fig. 8.

Pachyrrhynchus forsteni VOLLH., Tijdschr. v. Ent. 7 (1864) 168, pl. 12, fig. 4; HELLER, Philip. Journ. Sci. § D 7 (1912) 305.

Glossy bluish black; prothorax and elytra with white scale spots. Rostrum in apical half scatteredly punctured, basal half with a shallow oblong depression beset with a scale spot. Head distantly scatteredly punctured. Prothorax slightly longer than broad, very finely and scatteredly punctured, at anterior and posterior margins dorsolaterally with a small lateral scale spot and two not sharply defined spots in the middle at lateral margins. Elytra oblong-ovate, indistinctly striate-punctate, with four cross rows of small white scale spots. The first cross row, located at basal fourth, consists of four spots on each elytron, one of them dorsally, the others laterally; the second cross row, located in the middle, has seven or eight spots placed close together which do not reach suture or lateral margin. The third cross row, at apical third, consists of three spots and the fourth row is a transversely expanded spot next to apex. Legs sparsely and finely whitish setose.

Length, 12.5 millimeters (without rostrum); width, 5.5.

TERNATE; HALMAHERA; SUMATRA.

Pachyrrhynchus forsteni Vollh. is closely related to none of the Philippine *Pachyrrhynchus* species in the sense that *P. infernalis* Fairm. is to *P. orbifer* Waterh.; its nearest relative is *P. morotaiensis* Vollh., and these two are somewhat isolated representatives of the genus.

GROUP IV

Group IV is typified by *Pachyrrhynchus schoenherri* Waterh. and comprises relatively small species. The following species are placed in this group: *Pachyrrhynchus schoenherri* Waterh., *P. apocyrtoides* Schultze, *P. signaticollis* Schultze, *P. bucasanus* Schultze, *P. signatus* Schultze, *P. erichsoni* Waterh., and *P. semiignitus* Schultze.

Key to the species of Pachyrrhynchus, Group IV.

a^1. Elytra with distinct and well-defined roundish spots, not confluent, and without stripes.

b^1. Prothorax with two more or less roundish spots dorsolaterally in the middle, one toward each side.

b^2. Prothorax with a dorsally interrupted transverse band in the middle. **P. signaticollis Schultze.**

c^1. Prothorax without a scale line dorsally at anterior and posterior margins; spots on elytra small.

c^2. Prothorax with a scale line dorsally at anterior and posterior margins; spots on elytra large.......................... **P. bucasanus Schultze.**

d^1. Elytra without any sutural spots.

d^2. Elytra with two sutural spots and eight more on each elytron; general color of elytra glowing red...... **P. schoenherri Waterh.**

e^1. Elytra glossy dark green or coppery red with sixteen spots. **P. erichsoni Waterh.**

e^2. Elytra rather dull black, usually with eighteen spots. **P. erichsoni eschscholtzi Waterh.**

a^2. Elytra with ill-defined spots or more or less abbreviated longitudinal or transverse stripes.

f^1. Elytra without a sharply defined transverse stripe in the middle.

f^2. Elytra with a sharply defined transverse stripe or band in the middle; general color dark purplish violet. **P. signatus Schultze.**

g^1. General color black; prothorax with a spot toward each side in the middle, dorsolaterally; elytra with the spots not sharply defined...................... **P. apocyrtoides Schultze.**

g^2. General color glossy glowing red; prothorax without any dorsolateral spots; elytra with well-defined spots. **P. semiignitus Schultze.**

Pachyrrhynchus schoenherri Waterh. Plate 2, fig. 3 (lateral view); Plate 9, fig. 6.

Pachyrrhynchus schoenherri WATERH., Proc. Ent. Soc. London (1841) 19; Ann. & Mag. Nat. Hist. **8** (1841) 219; Trans. Ent. Soc. London I **3** (1843) 315; SCHOENH., Gen. Curc. Suppl. **8** (1845) 383; HELLER, Philip. Journ. Sci. § D **7** (1912) 307; SCHULTZE, Philip. Journ. Sci. **23** (1923) 78.

Glossy glowing red, prothorax and elytra with pale greenish scale spots. Related to *P. erichsoni* Waterh. Rostrum with a rather strongly pronounced depression in basal half, which extends almost to front. The latter with a roundish scale spot and another spot below each eye. Prothorax less subglobular than in *P. erichsoni,* with a small spot in the middle laterad and a larger spot at each lateral margin. Elytra with very faint traces of puncture rows. Each elytron with ten scale spots; two at base, three forming a cross row at the middle, one very large spot at the lateral margin, and two spots at apical third. Also a bifid sutural spot beyond the middle and another at apical fourth.

Female, length, 11 millimeters (without rostrum); width, 5.

Philippines, exact locality unknown.

This description is taken from a cotype specimen loaned by the British Museum.

Pachyrrhynchus erichsoni Waterh. Plate 3, fig. 1 (lateral view); Plate 9, fig. 15.

Pachyrrhynchus erichsoni WATERH., Proc. Ent. Soc. London (1841) 19; Ann. & Mag. Nat. Hist. **8** (1841) 219; Trans. Ent. Soc. London I **3** (1843) 315; SCHOENH., Gen. Curc. Suppl. **8** (1845) 383; HELLER, Philip. Journ. Sci. § D **7** (1912) 307, pl. 1, fig. 19; SCHULTZE, op. cit. **21** (1922) pl. 4, fig. 7.

Var. *chrysocompsus* HELLER, loc. cit.

Head, prothorax, and legs dark coppery red; elytra glossy, bronze or brass green in color. Prothorax and elytra with small roundish pale yellowish green scale spots. Rostrum, basal half with a shallow depression and strongly defined medial groove reaching to front, the latter with a scale spot. Sides of head with a scale spot below eye. Prothorax subglobular with a round scale spot in the middle toward each side and another at lateral margin. Elytra ovate, regularly and rather coarsely striate-punctate. Each elytron with eight roundish scale spots, two of which form a cross row near base, two in the middle, three in apical fourth, and one near apex. Mesosternum and

metasternum with a scale spot laterally. Penis structure, Plate 3, fig. 33.

Male, length, 9.5 to 13 millimeters (without rostrum); width, 4.5 to 5.6. Female, length, 12.5 millimeters (without rostrum); width, 6.

MINDANAO, Surigao Province, Surigao. DINAGAT (*my collector*). LEYTE, Cabalian (*Gregorio Lopez*). One specimen, from Leyte, has the general color of the elytra reddish coppery.

Specimens from the first two localities here given I consider typical, since they agree perfectly with the Waterhouse description, particularly with this author's remark that "it may be distinguished from either of the other species by its brass green color." Heller placed *P. eschscholtzi* Waterh. as a synonym of *P. erichsoni,* under the impression that it represented the female of *P. erichsoni.* I cannot agree with this since both sexes of the last-named species show the same general coloration, the same number of spots, as well as other small but constant differences in the form of the prothorax and elytra in comparison to *P. eschscholtzi.* Furthermore, the penis structures show that this organ in *P. erichsoni* is broader toward the point. For these reasons *P. eschscholtzi* is to be considered as a well-distinguished local race or subspecies of *P. erichsoni* Waterh.

Pachyrrhynchus erichsoni subsp. **eschscholtzi** Waterh. Plate 5, fig. 4.

> *Pachyrrhynchus eschscholtzi* WATERH., Proc. Ent. Soc. London (1841) 19; Ann. & Mag. Nat. Hist. **8** (1841) 219; Trans. Ent. Soc. London I **3** (1843) 316; SCHOENH., Gen. Curc. Suppl. **8** (1845) 383; HELLER, Philip. Journ. Sci. § D **7** (1912) 307, pl. 1, fig. 20.

Black; prothorax glossy. Each elytron with eight to ten yellowish green or pale flesh-colored scale spots. Two form a cross row at base, two or three in the middle, three or four in apical fourth, and one near apex.

Male, length, 10 to 10.5 millimeters (without rostrum); width, 4.8 to 5. Female, length, 12.5 millimeters; width, 5.8.

LUZON, Laguna Province, Paete, Mount Banahao. POLILLO (*Schultze*).

Var. *chrysocompsus* Heller has the dorsolateral spots of prothorax modified, forming reverse comma-shaped spots, the pointed end being slightly curved.

Pachyrrhynchus erichsoni and subspecies *eschscholtzi* seem to have the largest range of distribution of any species of the genus. It seems probable that further local races of *P. erich-*

soni will be found in such intermediate islands as Samar and Catanduanes, between Mindanao and Luzon.

Pachyrrhynchus signatus Schultze. Plate 2, fig. 4, ♀ (lateral view); Plate 5, fig. 13.

Pachyrrhynchus signatus SCHULTZE, Philip. Journ. Sci. 15 (1919) 551, pl. 1, figs. 6, 6*a*.

Dark, glossy, iridescent, violet purplish with pale green markings, rostrum and legs metallic copper colored. Closely related to *P. erichsoni* Waterh. Head with a small scale spot under each eye. Prothorax with a narrow anterior marginal band, another somewhat broader band at the middle interrupted discally, and traces of a posterior marginal band. Elytra with rows of distinct punctures. Each elytron with two large oblong-oval spots near base, one located discally, the other at lateral margin; at the middle a crossband, reaching from first row of punctures to eighth near lateral margin. At apical third a longitudinal stripe at third interstice, reaching to apex, recurving as a submarginal stripe, thus forming roughly a triangle, inside of which are located two oblong spots at fifth and seventh interstices, respectively.

Length, 11.6 millimeters; width, 5.5.

SIARGAO (*Schultze*).

Pachyrrhynchus bucasanus Schultze. Plate 2, fig. 1, ♀ (lateral view); Plate 5, fig. 10, ♀.

Pachyrrhynchus bucasanus SCHULTZE, Deutsche Ent. Zeitschr. (1922) 40, pl. 1, fig. 11, ♀.

Related to *P. erichsoni* Waterh. but much stouter in build. Glossy, dark wine red with violet sheen and pale yellowish green scale markings. Rostrum very similar to that of *P. apocyrtoides,* basal half depressed and flattened with a short but strongly pronounced longitudinal medial groove. A scale spot at sides of head. Prothorax as long as broad, with an anterior submarginal stripe and a short abbreviated posterior submarginal stripe dorsally. In the middle but toward each side a rather large irregular scale spot and a large roundish spot at each lateral margin. Elytra rather short ovate, strongly inflated, with moderately pronounced but regular rows of punctures. Each elytron with nine scale spots, forming cross rows, two at base, two in the middle, four others forming a cross row at apical third, and one, which is triangular, near apex. Legs metallic copper colored.

Female, length, 13 millimeters (without rostrum); width, 6.5.
BUCAS GRANDE (*Schultze*).

The spots in this species are much larger than in any other of the *P. erichsoni* group; also, it is one of the shortest and stoutest species of the genus.

Pachyrrhynchus signaticollis Schultze. Plate 1, fig. 28 ♂ (lateral view); Plate 9, fig. 2, ♂.

Pachyrrhynchus signaticollis SCHULTZE, Deutsche Ent. Zeitschr. (1922) 41, pl. 1, fig. 13.

Pachyrrhynchus transversarius HELLER, Stett. Ent. Zeitg. 84 (1923) 8.

Related to *P. erichsoni* Waterh. Head, prothorax, and legs glossy, elytra dull black. Rostrum in basal half with an oblong depression reaching to front and a very prominent longitudinal median groove reaching almost to vertex. Prothorax as long as broad, impunctate, with an irregular, pale reddish or pink crossband in the middle, interrupted discally but expanded spotlike at lateral margins. Elytra with regular rows of punctures, the punctures farther apart than in *P. erichsoni*. Each elytron with nine roundish pale reddish or pink scale spots which are placed in three cross rows, two near base, two at the middle, four at apical third, and one at apical triangle.

Male, length, 11 millimeters (without rostrum); width, 4.5.
MINDANAO, Agusan Province, Butuan (*C. M. Weber*).

Pachyrrhynchus apocyrtoides Schultze. Plate 1, fig. 27, ♂ (lateral view); Plate 9, fig. 3, ♂.

Pachyrrhynchus apocyrtoides SCHULTZE, Deutsche Ent. Zeitschr. (1922) 39.

Related to *P. erichsoni* Waterh. Head bluish black, prothorax, elytra, and legs dark brown with a violet sheen. Rostrum divergent toward apex, basal half uniformly depressed with a prominent short longitudinal medial groove. Prothorax glossy, slightly broader than long, with a narrow creamy white anterior submarginal scale stripe which extends to lateral margins, forming a large irregular scale spot. In the middle toward each lateral margin a small roundish spot. Elytra dull, finely coriaceous, with well-pronounced rows of punctures. Each elytron with three groups of irregular crossbandlike scale markings, the edges of which are not sharply defined. Two are located near base, another more fascialike at the middle, and a series of about five spots in apical third.

Male, length, 11 millimeters (without rostrum); width, 4.

MINDANAO, Bukidnon Province (*Schultze*).

Pachyrrhynchus semiignitus Schultze. Plate 1, fig. 22 (lateral view); Plate 9, fig. 12, ♂.

Pachyrrhynchus semiignitus SCHULTZE, Philip. Journ. Sci. 21 (1922) 581, pl. 2, fig. 9, ♂.

Head and prothorax glossy glowing red, elytra and legs metallic coppery. Elytra with pale green scale spots and stripes. Rostrum in apical half coarsely punctured, basal half with a strongly pronounced depression beset with some scattered scales. The dorsolateral edges swollen. Prothorax slightly broader than long, the sides moderately and evenly rounded. A narrow scale line along anterior and posterior margins, both lines confluent with a stripe on lateral margins. Elytra striate-punctate. Each elytron in basal third with a cross row of four larger oblong scale spots, between which are some smaller dots; in apical third between second and third puncture rows a longitudinal stripe confluent at apex with a short marginal stripe, the latter forming a V-shaped figure. Within this triangular figure two small spots form a lateral row. Underside coppery; mesosternum and metasternum with scattered scales and a large spot laterally. Femora with a patch of scattered scales on underside near apex.

Male, length, 11.5 millimeters (without rostrum); width, 5.6.

MINDANAO, Cotabato Province, Pikit.

This is also a somewhat isolated species.

(*To be concluded.*)

ILLUSTRATIONS

[Original black and colored drawings, except Plate 8, by W. Schultze; drawings of Plate 8 by Max Böhme. All colored figures enlarged about x 1.5.]

PLATE 1

FIG. 1. *Pachyrrhynchus infernalis* Fairm.
2. *Pachyrrhynchus orbifer* subsp. *azureus* Schultze, male.
3. *Pachyrrhynchus orbifer* Waterh., female.
4. *Pachyrrhynchus moniliferus* Germ., female.
5. *Pachyrrhynchus moniliferus* subsp. *chevrolati* Eyd. and Soul., female.
6. *Pachyrrhynchus zebra* Schultze, female.
7. *Pachyrrhynchus erosus* Schultze, male.
8. *Pachyrrhynchus annulatus* Chevrolat, female.
9. *Pachyrrhynchus annelifer* Heller, female.
10. *Pachyrrhynchus schuetzei* Schultze.
11. *Pachyrrhynchus igorota* Schultze, male.
12. *Pachyrrhynchus inclytus* Pasc., female.
13. *Pachyrrhynchus pulchellus* Behr., female.
14. *Pachyrrhynchus loheri* Schultze, female.
15. *Pachyrrhynchus psittaculus* Heller, female.
16. *Pachyrrhynchus semperi* Heller, female.
17. *Pachyrrhynchus argus* Pasc., female.
18. *Pachyrrhynchus ochroplagiatus* var. *multiplagiatus* var. nov., female.
19. *Pachyrrhynchus gemmatus* Waterh., female.
20. *Pachyrrhynchus congestus* Pasc., female.
21. *Pachyrrhynchus chamissoi* Schultze, female.
22. *Pachyrrhynchus semiignitus* Schultze.
23. *Pachyrrhynchus perpulcher* Waterh., female.
24. *Pachyrrhynchus stellio* Heller, male.
25. *Pachyrrhynchus decussatus* Waterh., female.
26. *Pachyrrhynchus gloriosus* Faust, female.
27. *Pachyrrhynchus apocyrtoides* Schultze, male.
28. *Pachyrrhynchus signaticollis* Schultze, male.
29. *Pachyrrhynchus multipunctatus* Waterh.
30. *Pachyrrhynchus roseomaculatus* Waterh.

PLATE 2

FIG. 1. *Pachyrrhynchus bucasanus* Schultze.
2. *Pachyrrhynchus baluganus* sp. nov.
3. *Pachyrrhynchus schoenherri* Waterh.
4. *Pachyrrhynchus signatus* Schultze, female.
5. *Pachyrrhynchus corpulentus* Schultze.
6. *Pachyrrhynchus amabilis* Schultze.

FIG. 7. *Pachyrrhynchus jugifer* Waterh.
8. *Pachyrrhynchus pseudoproteus* Schultze.
9. *Pachyrrhynchus atrocyaneus* Schultze, female.
10. *Pachyrrhynchus halconensis* Schultze, female.
11. *Pachyrrhynchus pinorum* Pascoe.
12. *Pachyrrhynchus consobrinus* Schultze.
13. *Pachyrrhynchus tristis* Heller.
14. *Pachyrrhynchus taylori* subsp. *metallescens* subsp. nov., male.
15. *Pachyrrhynchus taylori* Schultze, female.
16. *Pachyrrhynchus sanchezi* Heller, female.
17. *Pachyrrhynchus apicatus* Schultze.
18. *Pachyrrhynchus confusus* Schultze.
19. *Pachyrrhynchus rufopunctatus* Waterh.
20. *Pachyrrhynchus venustus* Waterh., female.
21. *Pachyrrhynchus absurdus* Schultze, female.
22. *Pachyrrhynchus postpubescens* Schultze.
23. *Pachyrrhynchus speciosus* Waterh., male.
24. *Pachyrrhynchus samarensis* sp. nov.
25. *Pachyrrhynchus regius* Schultze.
26. *Pachyrrhynchus latifasciatus* Waterh.
27. *Pachyrrhynchus circulatus* Heller.
28. *Pachyrrhynchus reticulatus* Waterh.
29. *Pachyrrhynchus reticulatus* subsp. *cruciatus* subsp. nov.
30. *Pachyrrhynchus phaleratus* Waterh., female.

PLATE 3

FIG. 1. *Pachyrrhynchus erichsoni* Waterh., male.
2. *Pachyrrhynchus sarcitis* Behrens, female.
3. *Pachyrrhynchus rugicollis* Waterh.
4. *Pachyrrhynchus sumptuosus* Schultze, female.
5. *Pachyrrhynchus sulphureomaculatus* Schultze.
6. *Pachyrrhynchus morio* Heller, female.
7. *Pachyrrhynchus sphaericollaris* sp. nov., male.
8. *Pachyrrhynchus lorquini* Chevrolat, male.
9. *Pachyrrhynchus chlorites* Chevrolat, male.
10. *Pachyrrhynchus benguetanus* sp. nov.
11. *Pachyrrhynchus ardentius* Schultze.
12. *Pachyrrhynchus libucanus* sp. nov.
13. *Pachyrrhynchus dubiosus* Schultze.
14. *Pachyrrhynchus tristis* Heller.
15. *Pachyrrhynchus ochroplagiatus* Heller.
16. *Pachyrrhynchus venustus* Waterh.
17. *Pachyrrhynchus pinorum* Pascoe.
18. *Pachyrrhynchus congestus* Pascoe.
19. *Pachyrrhynchus congestus* subsp. *coerulans* Kraatz.
20. *Pachyrrhynchus sanchezi* Heller.
21. *Pachyrrhynchus sumptuosus* Schultze.
22. *Pachyrrhynchus igorota* Schultze.
23. *Pachyrrhynchus decussatus* Waterh.
24. *Pachyrrhynchus phaleratus* Waterh.
25. *Pachyrrhynchus halconensis* Schultze.

FIG. 26. *Pachyrrhynchus argus* Pascoe.
27. *Pachyrrhynchus anellifer* Heller.
28. *Pachyrrhynchus moniliferus* Germar.
29. *Pachyrrhynchus orbifer* Waterh.
30. *Pachyrrhynchus rugicollis* Waterh.
31. *Pachyrrhynchus circulatus* Heller.
32. *Pachyrrhynchus reticulatus* Waterh.
33. *Pachyrrhynchus erichsoni* Waterh.
34. *Pachyrrhynchus apicatus* Schultze.
35. *Pachyrrhynchus halconensis* Schultze.
36. *Pachyrrhynchus gloriosus* Faust.
37. *Pachyrrhynchus inclytus* Pascoe.
38. *Pachyrrhynchus pulchellus* Behrens.
39. *Pachyrrhynchus morotaiensis* Vollh.
40. *Pachyrrhynchus forsteni* Vollh.

PLATE 4

FIG. 1. *Pachyrrhynchus ardentius* Schultze, female. Siargao Island.
2. *Pachyrrhynchus corpulentus* Schultze, female. Mindanao, Bukidnon, Lindabon.
3. *Pachyrrhynchus decussatus* Waterh. Catanduanes, Virac.
4. *Pachyrrhynchus postpubescens* Schultze, male. Mindanao, Bukidnon, Lindabon.
5. *Pachyrrhynchus absurdus* Schultze, female. Bucas Grande Island.
6. *Pachyrrhynchus speciosus* Waterh., male. Bucas Grande Island.
7. *Pachyrrhynchus gloriosus* Faust, female. Luzon, Laguna, Mount Banahao.
8. *Pachyrrhynchus gloriosus* var. *abbreviatus* Schultze, male. Luzon, Bontoc.
9. *Pachyrrhynchus ochroplagiatus* Heller, female. Luzon, Benguet. Mount Pulog.
10. *Pachyrrhynchus argus* Pascoe, female. Luzon, Benguet, Mount Santo Tomas.
11. *Pachyrrhynchus pinorum* Pascoe, female. Luzon, Benguet, Atoc.
12. *Pachyrrhynchus pinorum* var. *transversalis* Heller, male. Luzon, Benguet, Atoc.
13. *Pachyrrhynchus inclytus* var. *modestior* Behr., female. Luzon, Benguet, Mount Santo Tomas.
14. *Pachyrrhynchus pulchellus* Behr., female. Luzon, Benguet. Baguio.
15. *Pachyrrhynchus loheri* Schultze, female. Luzon, Bulacan, Mount Guinuisan.
16. *Pachyrrhynchus igorota* Schultze, female. Luzon, Benguet, Pauai (Haight's place).

PLATE 5

FIG. 1. *Pachyrrhynchus jugifer* Waterh., female. Panay, Jamindan.
2. *Pachyrrhynchus zebra* Schultze, female. Luzon, Benguet, Mount Santo Tomas.
3. *Pachyrrhynchus reticulatus* subsp. *cruciatus* Schultze. Luzon. Tayabas, Baler.

FIG. 4. *Pachyrrhynchus erichsoni* subsp. *eschscholtzi* Waterh. Luzon, Laguna, Paete.

5. *Pachyrrhynchus sumptuosus* Schultze, female. Luzon, Kalinga, Lubuagan.

6. *Pachyrrhynchus reticulatus* Waterh., female. Luzon, Laguna, Paete.

7. *Pachyrrhynchus circulatus* Heller, female. Catanduanes, Virac.

8. *Pachyrrhynchus congestus* subsp. *coerulans* Kraatz, female. Luzon, Bontoc, Mount Polis.

9. *Pachyrrhynchus multipunctatus* Waterh. Bohol.

10. *Pachyrrhynchus bucasanus* Schultze, female. Bucas Grande Island.

11. *Pachyrrhynchus orbifer* subsp. *azureus* Schultze. Luzon, Benguet, Kabayan.

12. *Pachyrrhynchus moniliferus* Germ., typical form. Luzon, Rizal, Montalban.

13. *Pachyrrhynchus signatus* Schultze, Siargao Island.

14. *Pachyrrhynchus moniliferus* subsp. *stellulifer*. Mindoro.

15. *Pachyrrhynchus stellio* Heller. Luzon, Bataan, Lamao.

16. *Pachyrrhynchus rugicollis* Waterh., female. Luzon, Zambales, Iba.

17. *Pachyrrhynchus congestus* subsp. *ocellatus* subsp. nov., male. Luzon, Benguet, Bokod.

18. *Pachyrrhynchus moniliferus* subsp. *stellulifer*. Mindoro.

19. *Pachyrrhynchus phaleratus* Waterh., female. Catanduanes, Virac.

20. *Pachyrrhynchus moniliferus* subsp. *chevrolati* Eyd. and Soul. Catanduanes, Virac.

PLATE 6

FIG. 1. *Pachyrrhynchus orbifer* var. *inornatus* Waterh., male. Luzon, Ilocos Norte, Bangui.

2. *Pachyrrhynchus orbifer* var. *circulifer* Chevr., female. Luzon, Ilocos Norte, Bangui.

3. *Pachyrrhynchus orbifer* Waterh. var., female. Luzon, Ilocos Norte, Burgos.

4. *Pachyrrhynchus orbifer* Waterh., female. Luzon, Ilocos Norte.

5. *Pachyrrhynchus orbifer* var. *ardens* Chevr., male. Luzon, Cagayan, Sanchez Mira.

6. *Pachyrrhynchus orbifer* Waterh. Luzon, Ilocos Norte.

7. *Pachyrrhynchus orbifer* Waterh. Luzon, Ilocos Norte.

8. *Pachyrrhynchus orbifer* Waterh. Luzon, Ilocos Norte.

9. *Pachyrrhynchus orbifer* subsp. *gemmans* Chevr., male. Luzon, Cagayan, Tuao.

10. *Pachyrrhynchus orbifer* Waterh. Luzon, Benguet, Baguio.

11. *Pachyrrhynchus orbifer* Waterh. Luzon, Benguet, Baguio.

12. *Pachyrrhynchus sphaericollaris* sp. nov. Luzon, Kalinga, Pinukpuk.

13. *Pachyrrhynchus gemmatus* Waterh., male. Luzon, Benguet, Baguio.

FIG. 14. *Pachyrrhynchus congestus,* Pascoe, female. Luzon, Benguet, Baguio.

15. *Pachyrrhynchus sanchezi* Heller, female. Luzon, Benguet, Baguio.

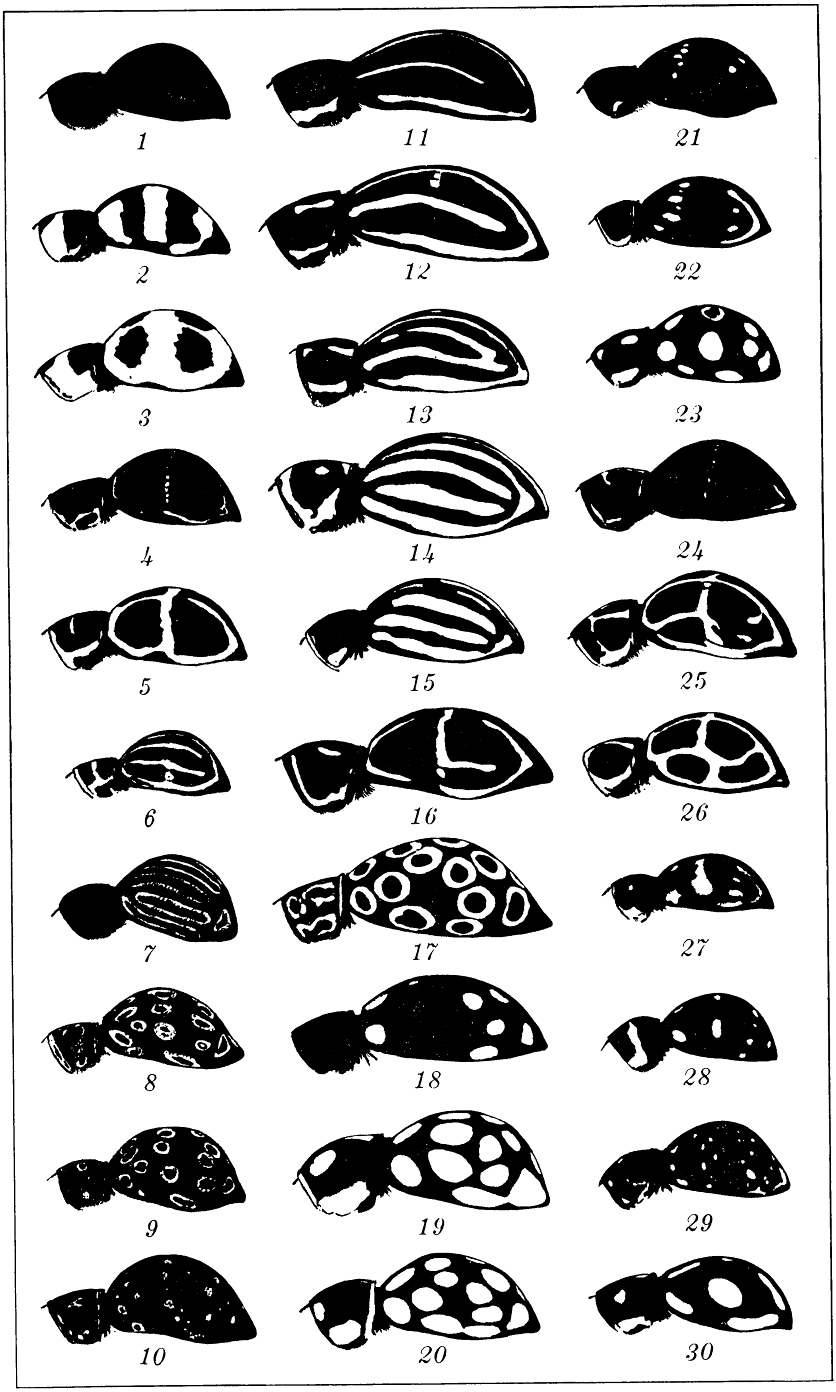
16. *Pachyrrhynchus sanchezi* Heller, male. Luzon, Benguet, Mount Mirador.

17. *Pachyrrhynchus anellifer* Heller, female. Luzon, Benguet, Irisan River.

18. *Pachyrrhynchus schuetzei* Schultze, female. Luzon, Benguet, Pauai (Haight's place).

19. *Pachyrrhynchus annulatus* Chevr., female. Luzon, Benguet, Mount Pulog.

20. *Pachyrrhynchus erosus* Schultze. Luzon, Benguet, Atoc.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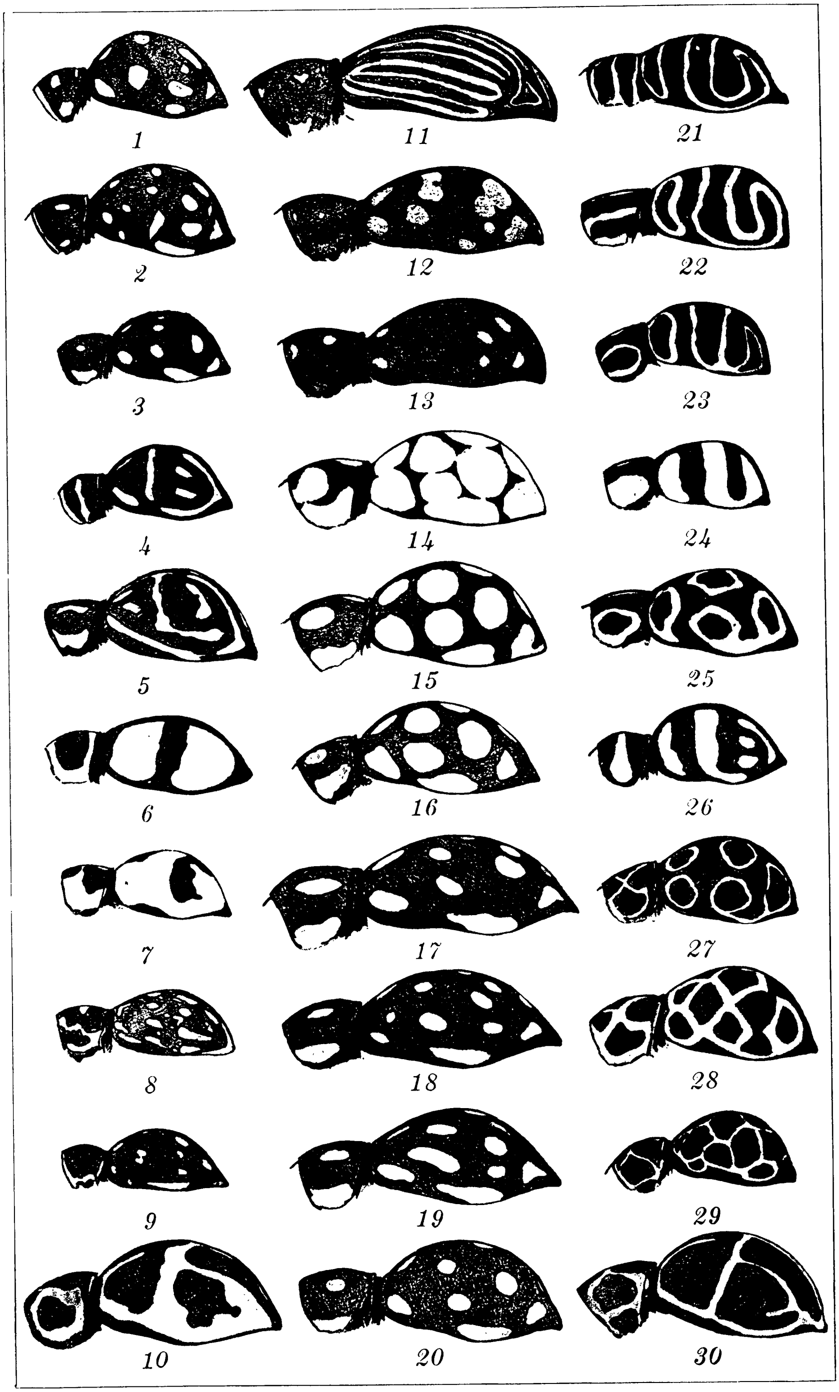
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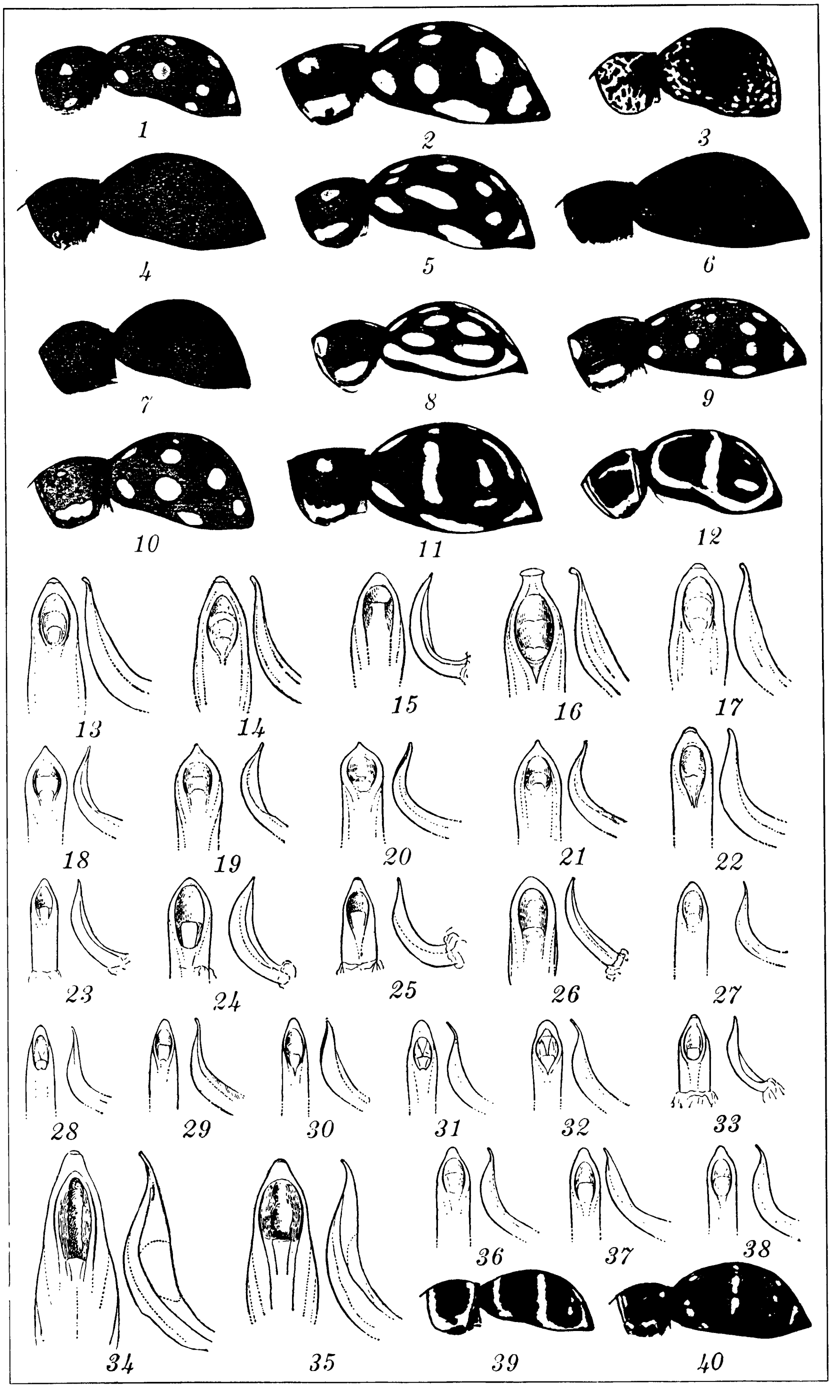
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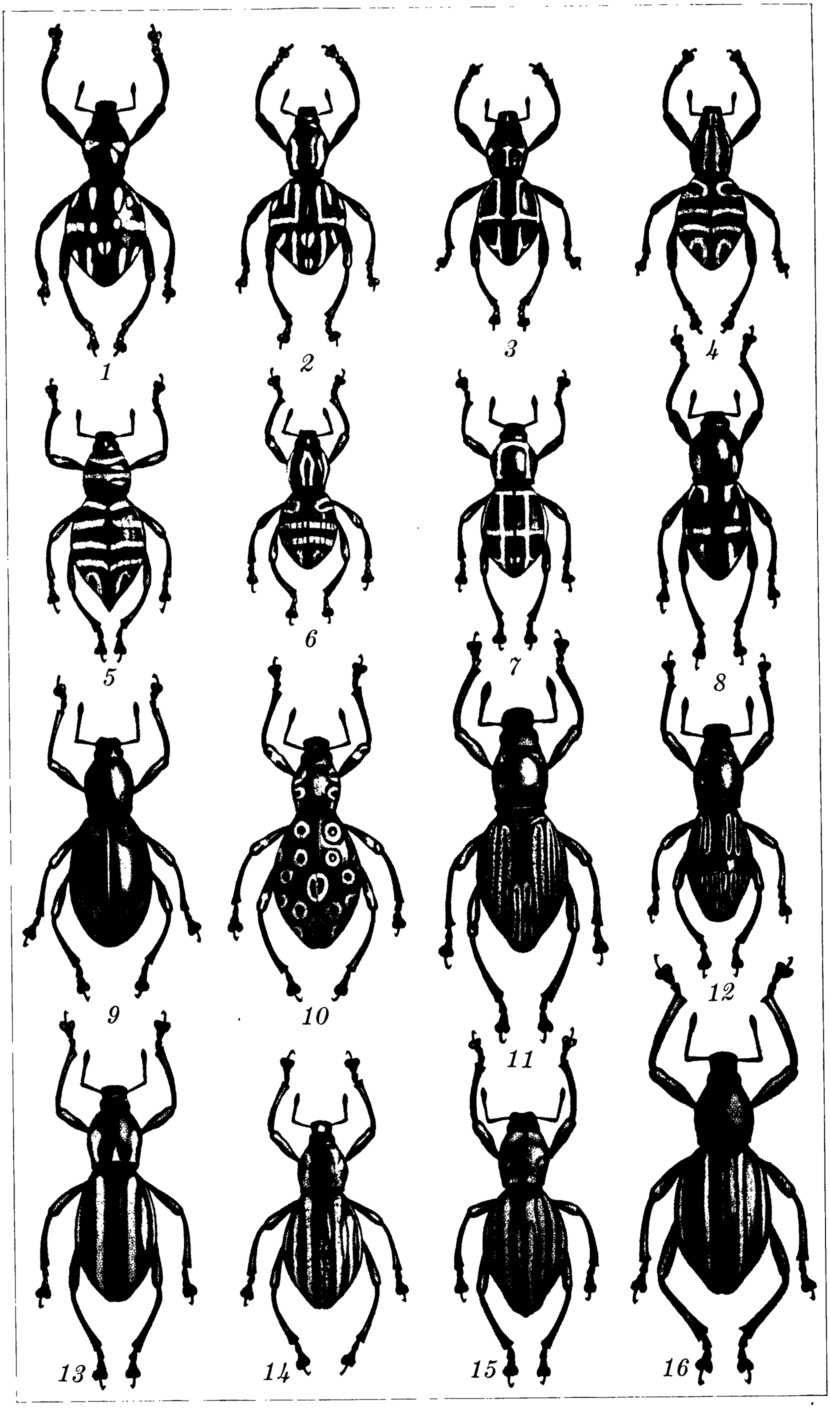

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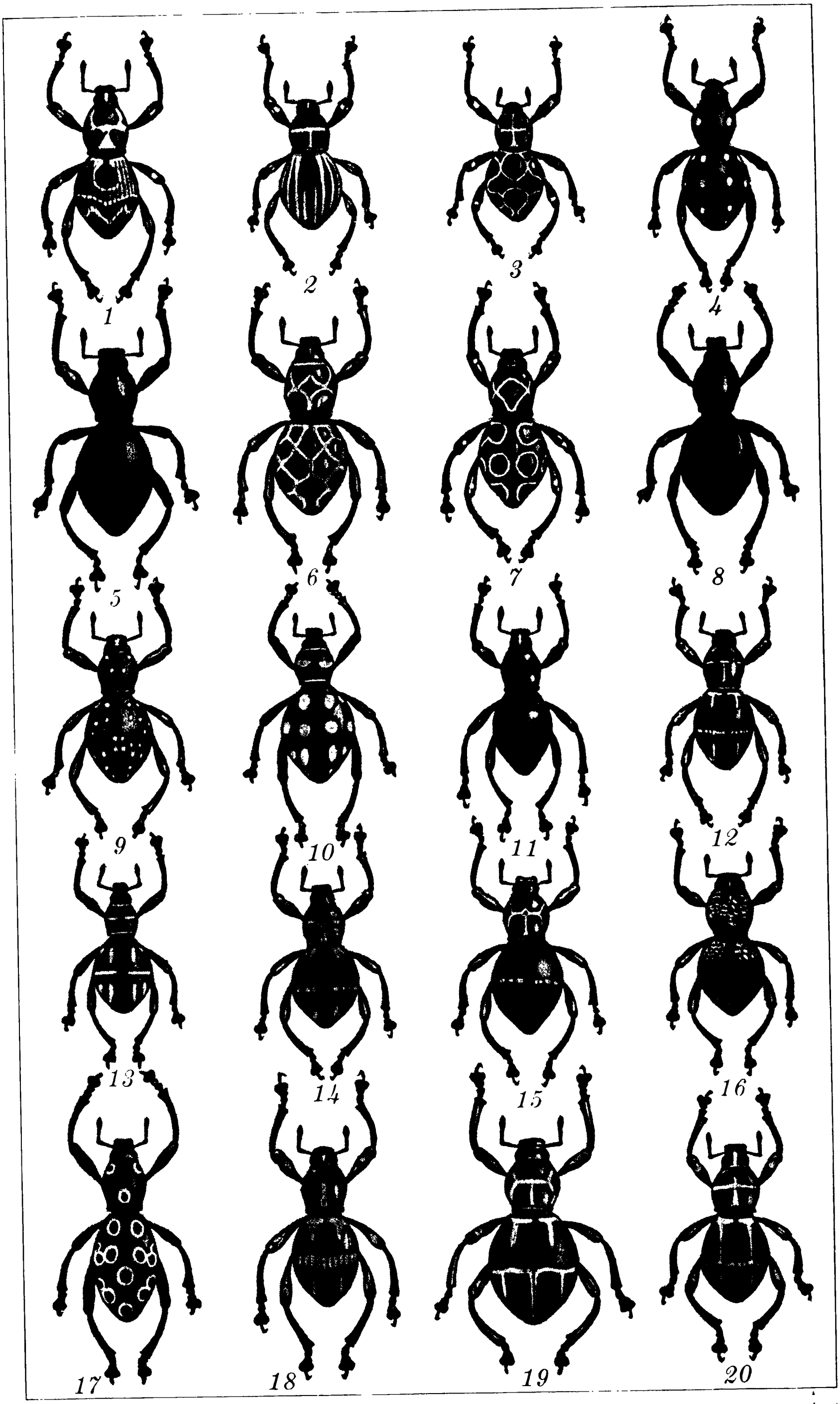

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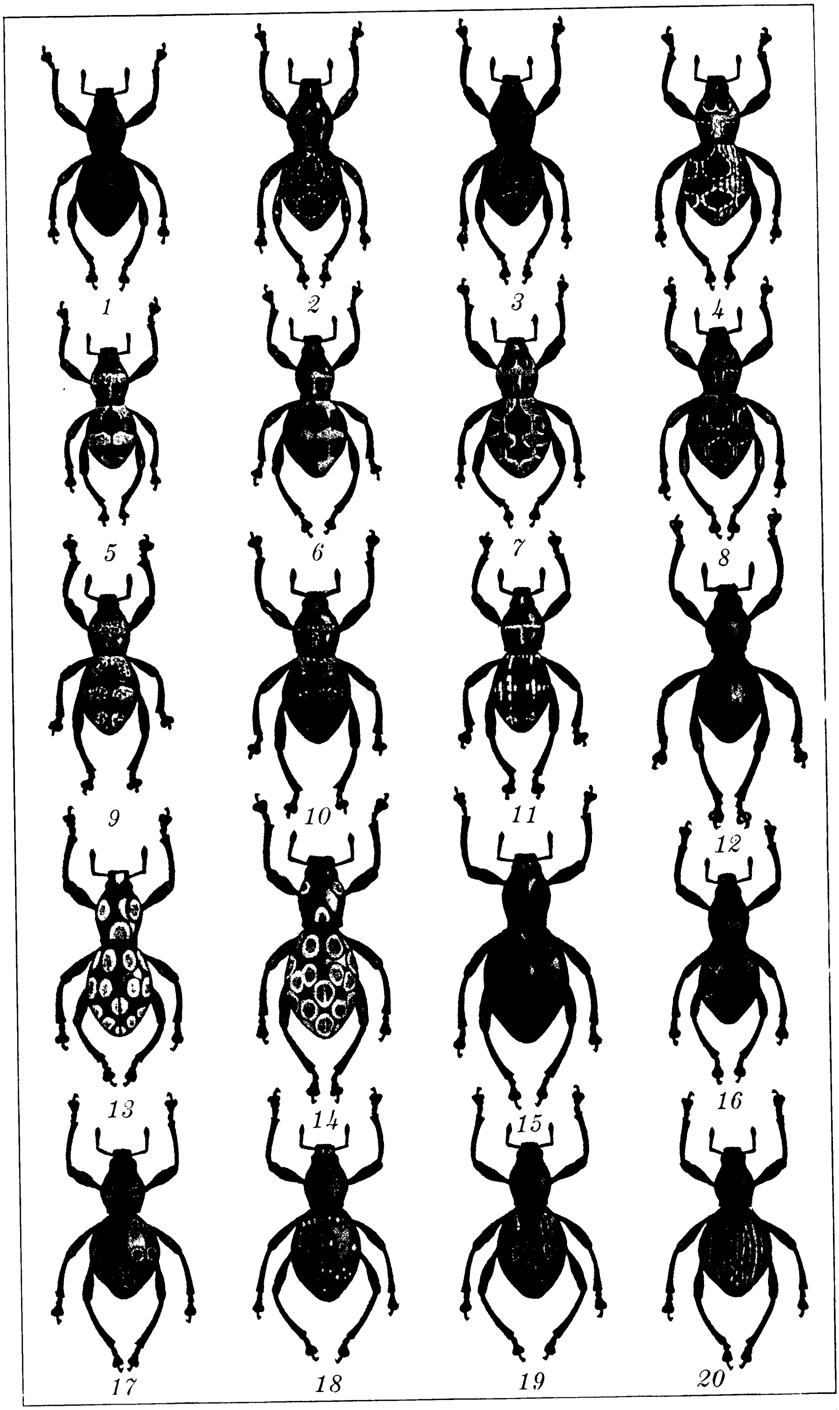

PLATE 6

ERRATUM

Page 330, line 29, *for* imen in von Winthem's *read* imen of *mediana* in von Winthem's.

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[New generic and specific names and new combinations are printed in **clarendon**; synonyms and names of species incidentally mentioned in the text are printed in *italic.*]

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